A Prospective Study Of

SHORT TERM OUTCOME ANALYSIS OF ARTHROSCOPY ASSISTED PERCUTANEOUS OSTEOSYNTHESIS FOR PATELLA FRACTURES

Dissertation submitted to

THE TAMILNADU DR M.G.R MEDICAL UNIVERSITY

CHENNAI - 600 032

In partial fulfilment of the regulations for the

Award of the degree of

M.S. (ORTHOPAEDIC SURGERY)

BRANCH –II

KILPAUK MEDICAL COLLEGE

CHENNAI - 600 010

APRIL 2014

CERTIFICATE

This is to certify that **Dr.CHERALATHAN.S**, post-graduate student (2012 - 2014) in the Department of Orthopaedic Surgery, Kilpauk Medical College, had done dissertation on **"SHORT TERM OUTCOME ANALYSIS OF ARTHROSCOPY ASSISTED PERCUTANEOUS OSTEOSYNTHESIS FOR PATELLA FRACTURES"**, under my guidance and supervision, in partial fulfilment of the regulation laid down by THE TAMILNADU DR.M.G.R. MEDICAL UNIVERSITY, CHENNAI – 32, for M.S. Orthopaedic surgery degree examination to be held in April 2014.

Prof. K.Raju, M.S.Ortho., D.Ortho.,
Professor of Orthopaedics,
Department of Orthopaedics,
Kilpauk Medical College,
Chennai – 10.
(Guide for the study)

Prof. N.Nazeer Ahmed, M.S.Ortho., D.Ortho.,
Professor and Head of the Department,
Department of Orthopaedics,
Kilpauk Medical College,
Chennai – 10.

Prof. P.Ramakrishnan, M.D., D.L.O.,
Dean,
Kilpauk Medical College,
Chennai – 10.

ACKNOWLEDGEMENT

I express my utmost gratitude to **Prof. P. RAMAKRISHNAN** M.D, D.L.O, Dean, Kilpauk Medical College, Chennai, for providing me an opportunity to conduct this study and for permitting me to use the hospital facilities for my study to the full extent.

I would like to express my sincere thanks and gratitude to my beloved Chief, **Prof. K.RAJU**, M.S. Ortho, D.Ortho, Professor of Orthopaedics, Kilpauk Medical College, Chennai -10, who allotted me this topic and kindly accepted to be my guide for the study and offered valuable suggestions to make this study a successful one.

I would like to express my gratitude and reverence to my beloved Head of Department, **Prof. N.NAZEER AHMED**, M.S. (Ortho), D.Ortho, whose guidance and help has elevated me to this level, to conduct this study successfully. I sincerely thank him for the expert guidance and constant encouragement to conduct this study.

I wish to express my sincere gratitude and heartfelt thanks to **Prof.N.O.SAMSON JEBAKUMAR,** M.S.(Ortho), D.Ortho. and **Prof.R.BALACHANDRAN,** M.S.(Ortho), D.Ortho. and **Prof.S.ANBALAGAN,** M.S.Ortho., D.Ortho., DNB Ortho for their encouragement.

I am deeply indebted to my beloved Assistant Professors

Dr.G.MOHAN, M.S.Ortho, DNB.Ortho, MNAMS,

Dr.C.ANANTHARAMAN, M.S.Ortho.,

Dr.SAMUEL GNANAM, M.S.(Ortho), D.Ortho,

Dr.SUKUMARAN, M.S.Ortho., D.Ortho.,

Dr.PRABAKARAN M.S.Ortho., D.Ortho.,

not only for guiding me in every aspect of this study but for the whole of my postgraduate career as well through their valuable advice and guidance.

I wish to express my thanks to anesthesiologists, postgraduate colleagues, staff members, and theatre staff for the help they have rendered.

I thank all my patients who gave full cooperation for this study without whom this study wouldn't been possible.

DECLARATION

I, **Dr.CHERALATHAN.S**, solemnly, declare that this dissertation titled **"SHORT TERM OUTCOME ANALYSIS OF ARTHROSCOPY ASSISTED PERCUTANEOUS OSTEOSYNTHESIS FOR PATELLA FRACTURES"** is a Bona fide work done by me at Kilpauk Medical College, during the period from 2012 to 2014, under the guidance and supervision of my Unit Chief **Prof. K.RAJU,** M.S. (Ortho), D.Ortho. This dissertation is submitted to "THE TAMILNADU DR MGR MEDICAL UNIVERSITY", towards partial fulfilment of regulations for the award of M.S.DEGREE BRANCH II in Orthopaedic Surgery.

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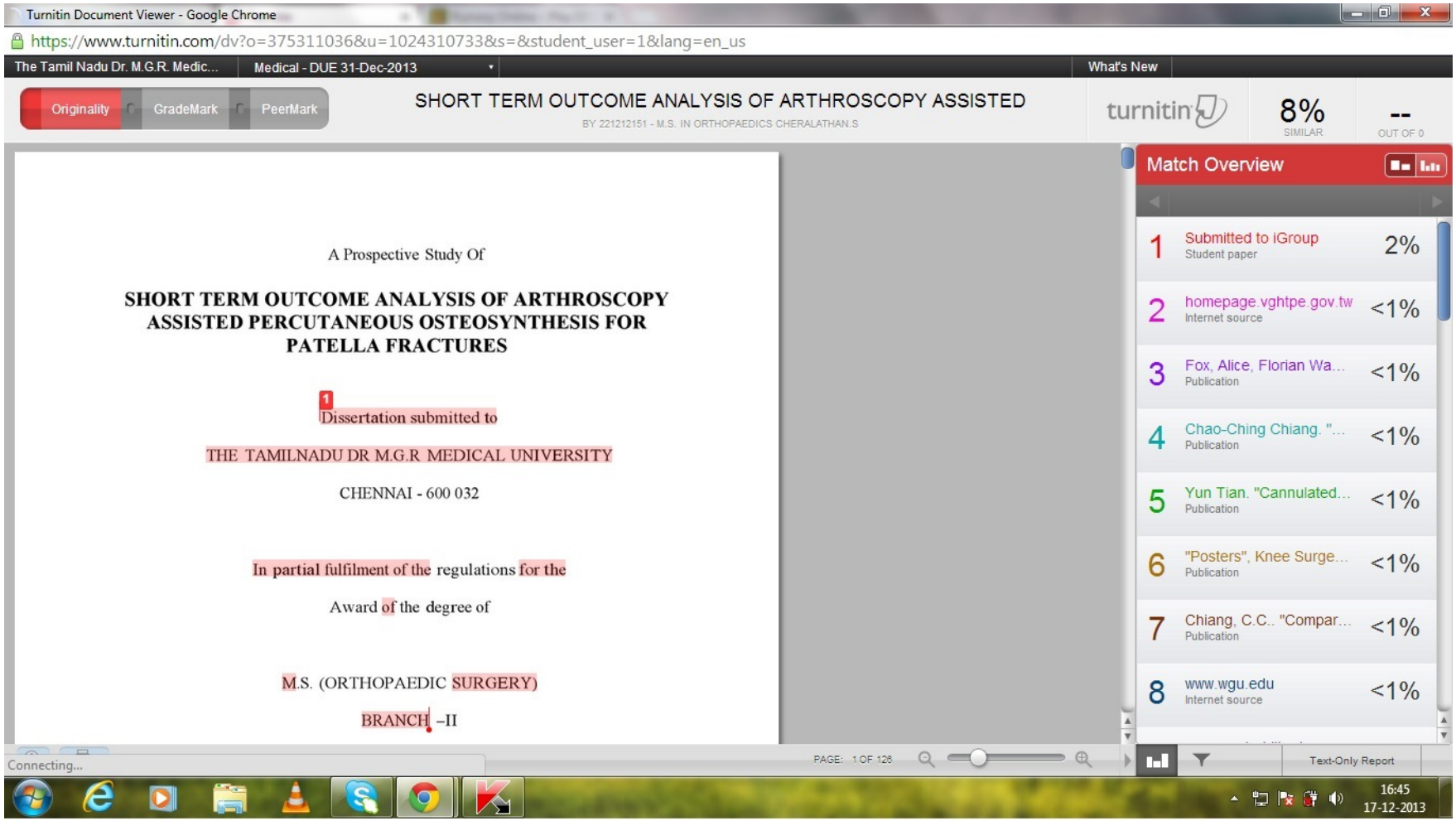


CONTENTS

SHORT TERM OUTCOME ANALYSIS OF ARTHROSCOPY ASSISTED PERCUTANEOUS OSTEOSYNTHESIS FOR PATELLA FRACTURES

ABSTRACT

Introduction:

Patellar fractures constitute about 1% of all skeletal injuries put together. The present standard treatment options available mainly involve open reduction and internal fixation with various types of implants. In spite of good results the disadvantages of open reduction still pose problems. Recent interest in minimally invasive osteosynthesis has given rise to percutaneous techniques in fixation of many fractures. POMC (Percutaneous Osteosynthesis using Modified Carpenter's) technique in fixation for transverse patellar fractures has shown good results in recent literature.

Aim of study:

This study aims to determine the usefulness of a POMC technique for surgical treatment of transverse fractures of patella, with regards to fracture union, functional outcome and being minimally invasive.

Materials and methods:

This prospective study involved 20 patients with transverse fracture pattern of patella, all were operated by POMC technique, which involves percutaneous reduction

and internal fixation for transverse fractures of patella using 4.0 mm cannulated cancellous screws supplemented with percutaneous anterior tension band wiring through the screws, with 18 G stainless steel wire in a horizontal figure of eight configuration with two knots. The above technique involves arthroscopy and fluoroscopy where the former is used in the direct visualisation of the accurate reduction of the articular surface and the latter is used to confirm the same and aid in implant positioning. All patients were subjected to a standard post-operative protocol and followed up for a minimum period of 6 months. They were objectively assessed by clinico-radiological methods and subjectively assessed using Lysholm knee scoring system.

Results:

The overall results showed that 75% of the patients had excellent results by subjective analysis using the Lysholm knee scoring scale and 90% union rate by clinic-radiological assessment.

Conclusion:

This short term study proves that POMC technique is an effective treatment method for transverse patellar fractures. But still need long term follow-up studies to establish this method as a standard treatment procedure.

KEYWORDS

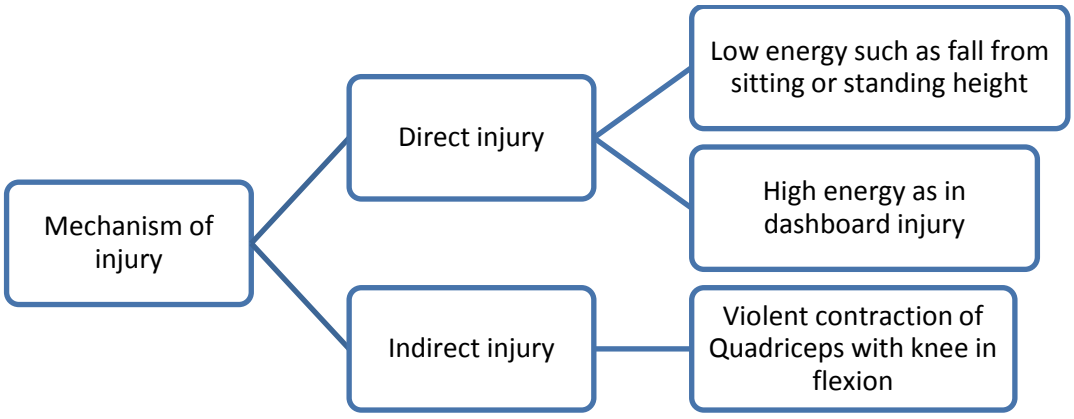
1. Percutaneous osteosynthesis for patella
2. Modified Carpenter’s technique
3. Arthroscopy assisted internal fixation for patella
4. Minimally invasive patella osteosynthesis
5. Lysholm knee score in patella fractures

Introduction

Patella is the largest sesamoid bone in the human body, with a subcutaneous location embedded within the tendon of Quadriceps muscle of thigh. The superficial location makes it prone to injuries due to direct forces around knee [(1)]. Indirect force namely sudden violent contraction of Quadriceps also causes patellar fracture. Incidence of patellar fractures is about 1% of all skeletal injuries put together [(2)]. More common among males with a ratio of 2:1 [(3)]. Commonly occurs in the age group between 20 to 50 years [(4)].

The history of operative treatment for patellar fractures dates back to 1843, when Malgaigne designed the Griffe metallique, a metal claw attached to sliding plates meant for holding the fractured fragments of patella together [(5)]. The first surgeon to perform open reduction and internal fixation for patellar fracture was Sir Hector Cameron of Glassgow, Scotland, in 1877, using interfragmentary wiring [(6)]. From then onwards many techniques using various implants have been described.

The mechanism of injury is noted in the following flow chart.



The treatment plan for patellar fractures depends on the fracture pattern, involvement of extensor mechanism, age, bone quality, patient expectation and presence of associated injuries. The commonly followed management protocol is as follows [1].

- Non displaced fractures are managed with conservative measures such as cylinder cast or knee brace.
- Displaced fractures are managed according to the fracture pattern, the options being Modified anterior tension band, Lag screws, Longitudinal anterior band, Cerclage wiring, Partial or Total patellectomy. The contraindications being critically ill patient, evidence of infection in soft tissue or bone and non-ambulatory patient.

The effectiveness of each treatment option has been shown with its own merits and demerits and discussed in detail in literature. Though most of the studies involve open reduction with internal fixation for patellar fractures, there have been recent literature support for closed reduction and internal fixation for displaced patellar fractures. This study is done as a short term outcome analysis on the effectiveness of POMC (Percuateous Osteosynthesis using Modified Carpenter's technique), which includes arthroscopy assisted percutaneous osteosynthesis of displaced patella fracture using Modified Carpenter's technique which involves fixation with 4.0 mm cannulated cancellous screw system combined with anterior tension band principle developed by AO/ASIF (Arbeitsgemeinschaft fur Osteosynthesefragen/Association for the Study of Internal fixation) group both done percutaneously.

The desired advantages of this procedure being

- Protection of soft tissue architecture as it is minimally invasive
- Rigid fixation proven to be better than the popular Modified tension band wiring by recent publication.
- Earlier rehabilitation
- Reduced post-operative pain
- Minimal scar

Though not widely used at present, this technique may prove to be a better alternative to other methods after long term follow up studies.

Aim of study

To do a short term analysis of the outcome of percutaneous osteosynthesis of transverse fracture of patella using modified Carpenter's technique. The analysis was planned to comprise of a subjective and objective outcome analysis. The subjective analysis was planned to be done using Lysholm Knee Scoring scale. The objective analysis was planned based on serial clinical examinations and radiological examination during follow-up studies. Since patellar fractures unite in an average period of 12-14 weeks, the total duration of follow-up was fixed as 6 months.

Analysis of the effectiveness of the percutaneous osteosynthesis in maintaining the fracture reduction until union, from the data collected during the follow-up was the main aim of study. Apart from the above analysis, the possible complications with this procedure both per-operative and post-operative, was also analysed, using the data collected.

Review of literature

Chao-Ching Chiang et al., in their retrospective analysis involving 21 patients with transverse patellar fractures, operated by arthroscopy assisted percutaneous patella osteosynthesis using cannulated cancellous screws and figure of eight tension band wiring, have concluded that the results of this technique of fixation of transverse patellar fractures was comparable to open reduction and internal fixation. They have described the above technique as Percutaneous Osteosynthesis by Modified Carpenter's technique (POMC) [(7)].

The actual Carpenter's technique being Open reduction and internal fixation with cannulated cancellous screw and tension band wiring in horizontal configuration through the screws, described during instructional course lecture of American Academy of Orthopaedic Surgeons (AAOS) authored by James E. Carpenter, Roberta Kasman, Larry S. Mathews [(8)].

James E. Carpenter et al. in another biomechanical study using 18 cadaver knees, to model as acute patellar fractures, compared three surgical techniques:

I. Modified Tension Band wiring (AO Technique)
II. Fixation with two parallel 4.5 mm Interfragmentary lag screws
III. Fixation with 4 mm cannulated cancellous screws for interfragmentary compression supplemented with tension band wiring

The knees were subjected to mechanical testing and the amount of interfragmentary separation, in simulated knee extension and maximum load to failure at 45^{o} of flexion were analysed. The conclusion was that the fixation with 4 mm cannulated cancellous

screws supplemented by tension band wiring possessed the maximum resistance to load [(9)].

Tandogan et al. have published a case series of patella fractures, treated by arthroscopy assisted percutaneous osteosynthesis by cannulated cancellous screws and tension band wiring through the screws. They have concluded that this technique has the advantages of being minimally invasive, not disturbing the patellar vascularity, clear visualisation of the fracture reduction, stable fixation with rigid implants and aids in early post-operative rehabilitation. Limitations being not suitable for fractures with rupture of extensor mechanism and wide displacement of fragments [(10)].

Berg, Eugene E. had treated 10 patients with transverse fracture of patella, with cannulated cancellous screw for interfragmentary compression supplemented with tension band wiring through the cannulated cancellous screws and achieved results equivalent to modified tension band wiring. He has also listed the following as the advantages of this construct:

I. Low profile construct
II. Less irritation of soft tissues by implant
III. Early rehabilitation with restricted range of motion exercises
IV. Salvage procedure in cases of failed traditional tension band wiring in osteoporotic bone.

In all patients Berg, Eugene E. had used standardized rehabilitation protocol that included early continuous passive range of motion exercises and had achieved good results [(11)].

Yun Tian et al., in the retrospective analysis of 101 patients with patellar fractures, have made a comparative study between modified tension band wiring and titanium cable - cannulated screw tension band technique and have come to a conclusion that the latter method showed superior results with regards to fracture reduction, healing time and better Iowa score for knee function [(12)].

Onder Baran, Metin Manisali and Beriven Cecen in their biomechanical study of Patella, fixed with modified tension band technique, involving cyclical loading test and knee MRI studies, have concluded that tension band is the main stability factor for patellar fracture fixation especially when the knee is in flexion but more stability and durability could be achieved by transferring the tension load directly to the bone rather that by applying it to the soft tissues as is done in the modified tension band technique. They have also reported that excessive initial compression caused bending of the Kirschner wire, which could be avoided by using more rigid implant [(13)].

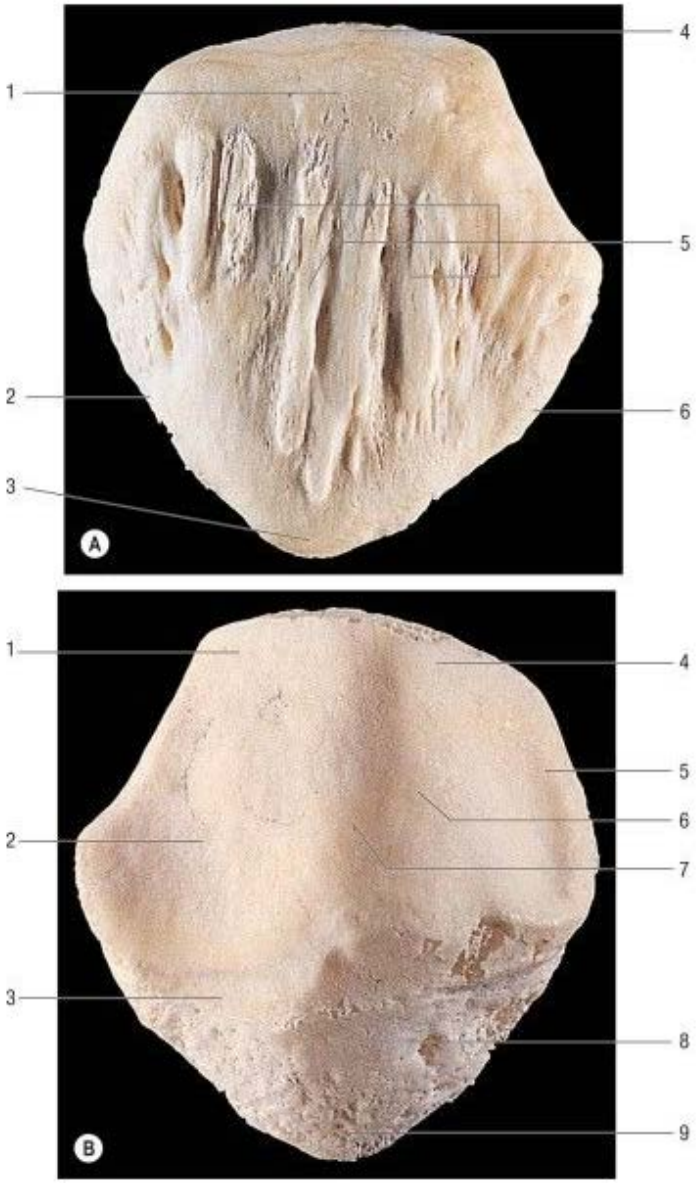
J.John, W.W.Wagner, J.H.Kuiper in their biomechanical investigation analysing the effect of the site of wire twist, placed in the stainless steel wire for application of tension band wiring, have concluded that a horizontally oriented figure of eight with wire twists at the adjacent corner provided the most stable construct and resistance to failure while applying cyclical load tests [(14)].

Weber et al. had recommended threading the wire for tension band technique, directly through the bone rather that threading it through the soft tissue. This provides more stable fixation and permits early rehabilitation in post-operative patients [(15)].

Anatomy

Bony Anatomy [16]**:**

Patella is the triangular shaped [17] largest sesamoid bone of the body embedded within the tendon of Quadriceps.



A. Left patella: Anterior aspect

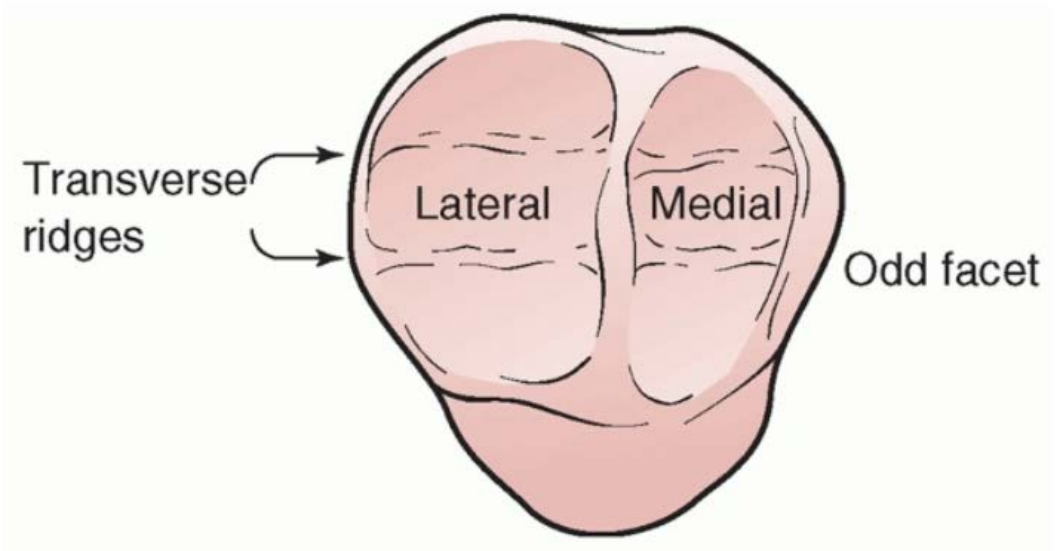
1. Area of attachment of Rectus femoris; 2. Medial border attachment of medial retinaculum; 3. Apex; 4. Area of attachment of Vastus intermedius; 5. Markings of attachment of Quadriceps tendon; 6. Lateral Border: Attachment of lateral retinaculum

B: Left Patella articular surface

1. Upper lateral facet: in contact with femur in flexion; 2. Lower lateral facet: in contact with femur in extension; 3. Area overlain by edge of circumferential fat pad; 4. Upper medial facet : in contact with femur in flexion; 5. Medial vertical (Odd) facet in contact with femur in extreme flexion 6. Lower medial facet: in contact with femur in extension. 7. Ridge 8. Area covered by infrapatellar fat pad 9. Area for attachment for patellar tendon.

It is a flat bone with anterior and posterior surfaces, three borders namely superior, medial and lateral, tapered inferiorly with an apex. The anterior surface is flat [18] and ridged longitudinally, perforated with many nutrient holes, deep to the prepatellar bursa, covered by expansion from the Quadriceps tendon which blends distally with the superficial fibres of the patellar tendon.

The posterior surface has articular and non-articular area. The articular area is covered by cartilage which is the thickest in the human body. The articular area is divided into medial and lateral facet by the longitudinal ridge, which conforms to the trochlea of the distal femur. The individual facets are further subdivided into superior, middle and inferior by two horizontal facets [17] [19]. The seventh facet which is known as the Odd facet or medial vertical facet articulates with femur in extremes of flexion.



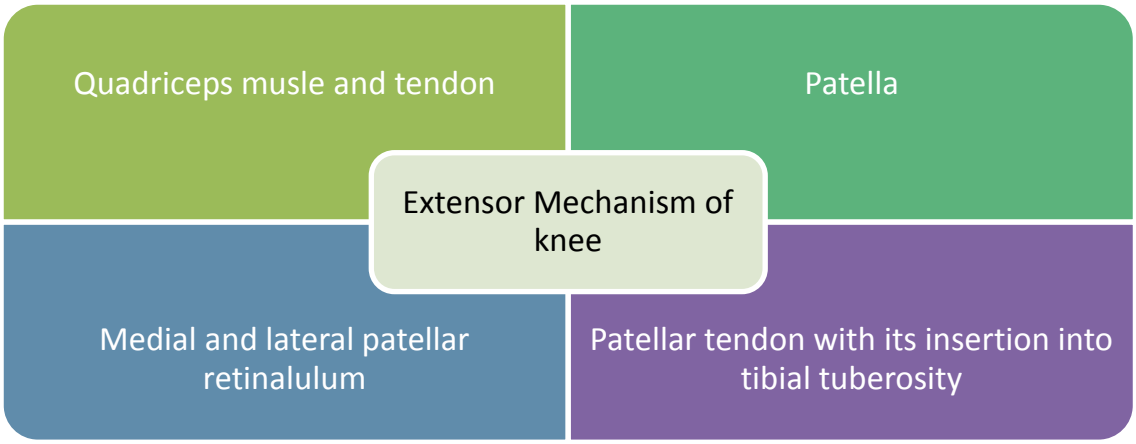
Wiberg [20] in his study has classified the patellar morphology with regards to the variable magnitude of the medial and lateral facet.

Type I	**Concave and approximately equal sized medial and lateral facet**	**Note: Types IV and V were later added by Baumgartl [21], on to original Wiberg classification which had only three types.**
Type II	Medial facet is concave and smaller than the lateral facet	
Type III	Medial facet is convex and smaller than lateral facet	
Type IV	Small steeply sloped medial facet with a medial ridge	
Type V	Also known as Jaegerhut patella, is devoid of medial facet or vertical ridge	

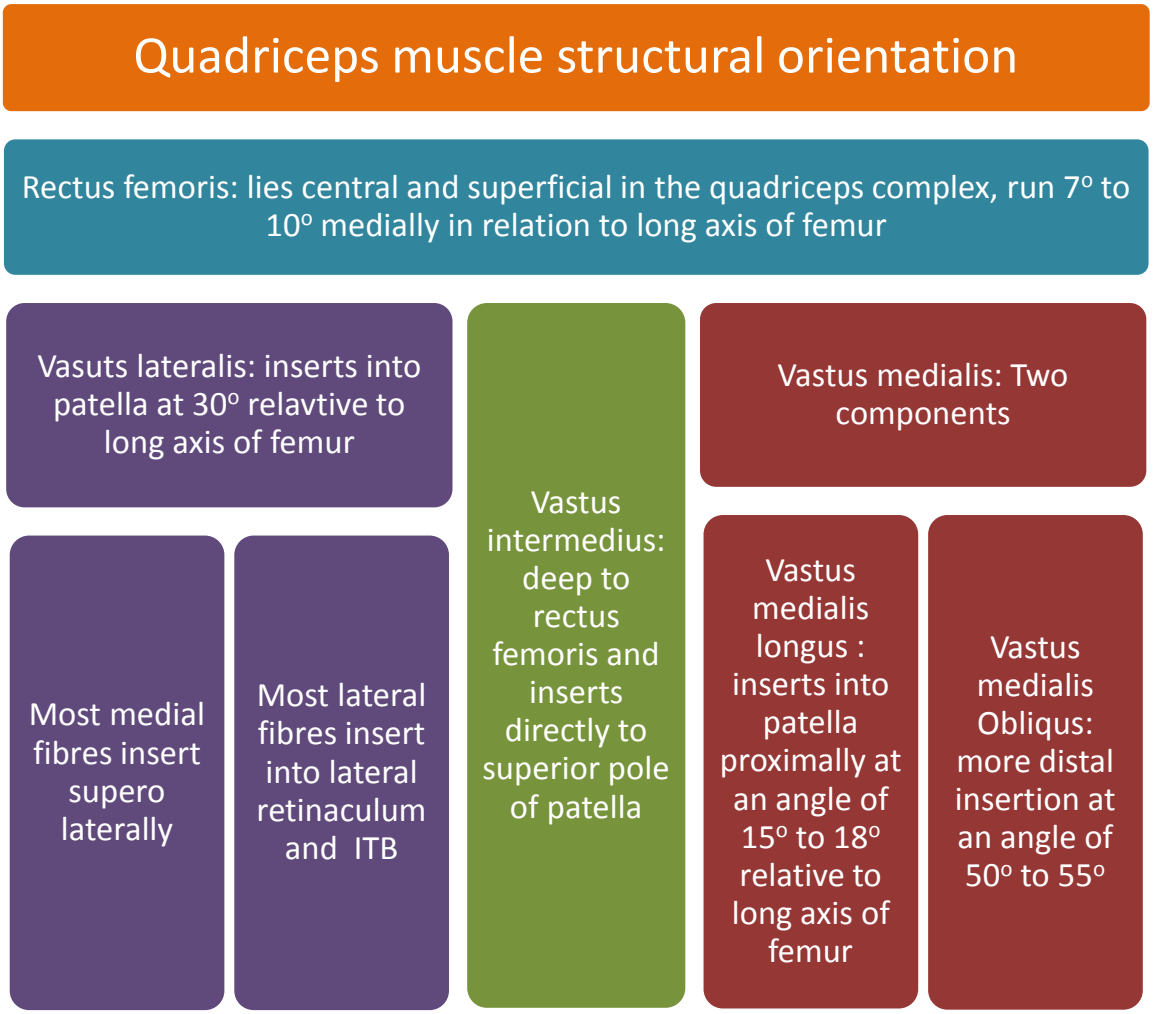
Distal to the articular surface is the roughened non-articular surface which has the attachment of patellar tendon and is covered by the infrapatellar pad of fat. The thick superior surface (border) slopes antero-inferiorly, while the medial and lateral borders are thin and converge distally to form the apex. Patella comprises of more or less uniformly dense trabecular bone, covered by a thin plate of compact lamina. Anterior trabeculae are parallel to the surface whereas the posterior trabeculae radiate from the articular surface into the substance of the bone.

Soft tissue anatomy:

Patella is embedded in the soft tissue coalition deep to facia lata and forms an integral part of the Extensor mechanism, the components of which are illustrated in the figure.

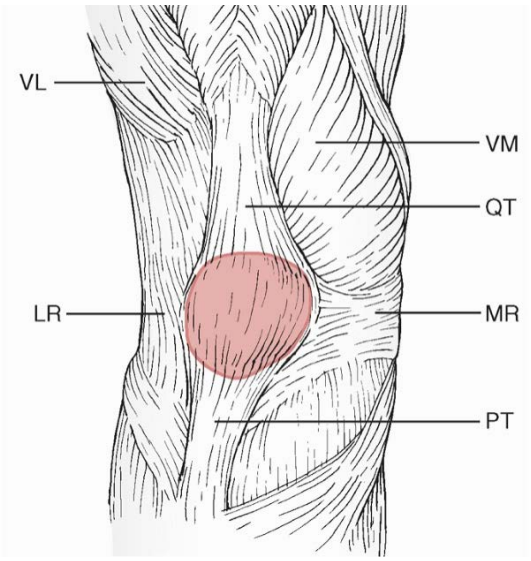


Structural Orientation of Quadriceps muscle [22] [23],



Patellar retinaculum and Iliotibial band function as secondary extensors of knee. The continuation of the deep investing fascia lata fibres get blended with aponeurotic fibres from Vastus medialis and lateralis [24].

Vastus medialis and lateralis inserts onto the proximal tibia to form patellar retinaculum. Therefore in isolated patellar fractures, these soft tissue structures can perform active knee extension [18].



Anterior Aspect of Left Knee showing soft tissue supports for patella

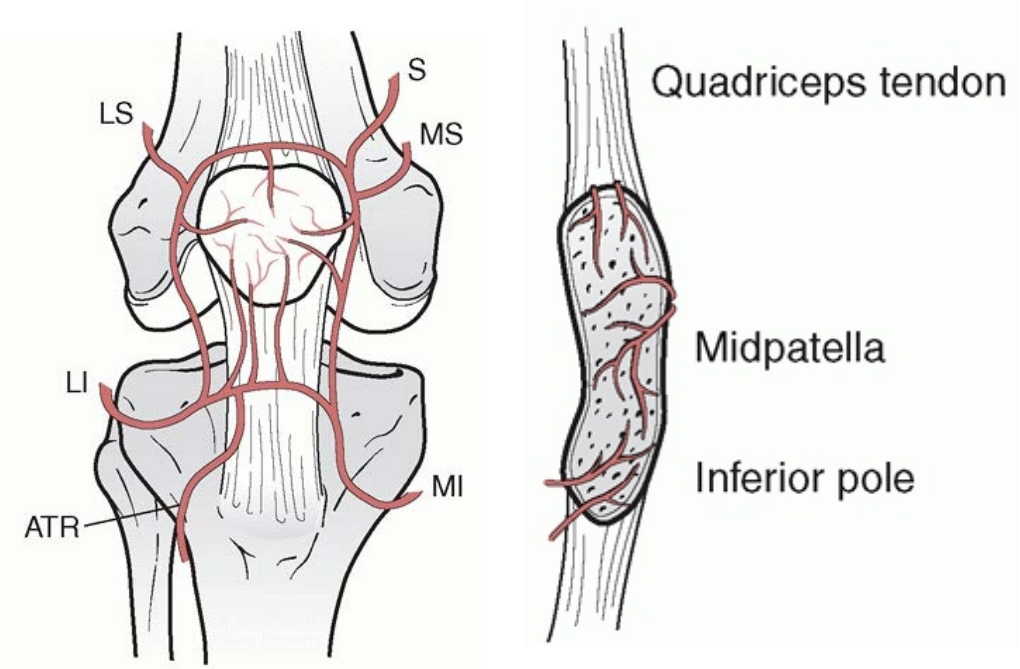
1. VL : Vastus lateralis
2. VM : Vastus medialis
3. QT : Quadriceps tendon
4. LR : Lateral Retinaculum
5. MR : Medial Retinaculum
6. PT : Patellar tendon

The most important structure among the static medial patellar stabilizers is the medial patella-femoral ligament contributing 50% to 60% [24] of the restraining force preventing lateral patellar subluxation [25]. It is a fan shaped structure running postero-superiorly from the upper medial border of patella to the femoral insertion on medial femoral epicondyle just anterior to medial collateral ligament [25] [24] and just distal to adductor tubercle, measuring 58.8 ± 4.7 mm in length and 12.0 ± 3.1 mm in width and inclined 15.9 ± 5.6 degrees proximally [24]. The Vastus medialis obliqus muscle is the important dynamic medial stabiliser of patella.

The average length of patellar tendon is 50 mm, arising from apex of patella, inserting into the tibial tubercle. Primarily constituted by the continuation fibres from the central rectus femoris tendon and is reinforced medially and laterally by extensor retinaculum, supplemented by iliotibial tract laterally [23].

Arterial Blood Supply

Supplied by extensive dorsal plexus of arteries that can be separated into extraosseus and intraosseus system, formed by six separate arteries. This helps to preserve vascularity even in the cases of communited fractures [26].



The supreme geniculate artery (S) arises from the femoral artery. The recurrent anterior tibial artery (ATR) arises from the tibial artery. Other 4 branches namely medial and lateral superior and inferior geniculate artery arises from the popliteal artery. Scapinelli [27] has shown that primary intra-osseous supply enters into the middle third anterior aspect and distal pole supplying the proximal part in retrograde manner.

Biomechanics

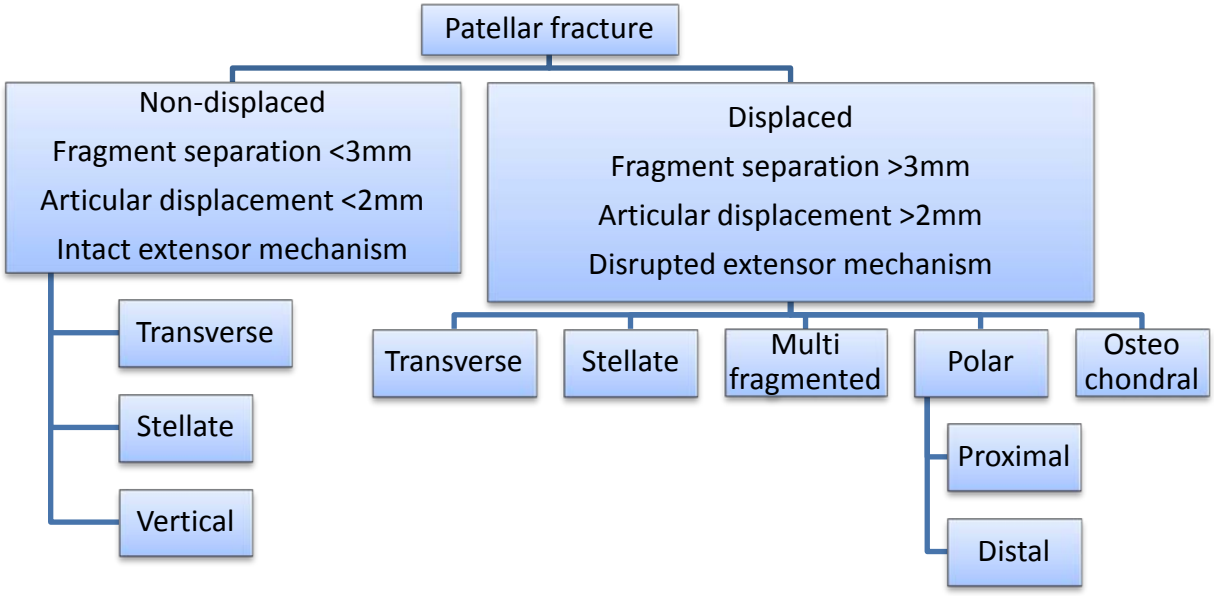
Active knee extension brought about by extensor mechanism is essential not only to maintain erect posture but also in activities of daily living such as walking, ascending or descending stairs, rising from chair or squatting position [28]. All these activities require immense force to overcome gravity. The critical biomechanical function of linking and displacement is provided by Patella [28]. The biomechanical functions of patella can be understood from the following table.

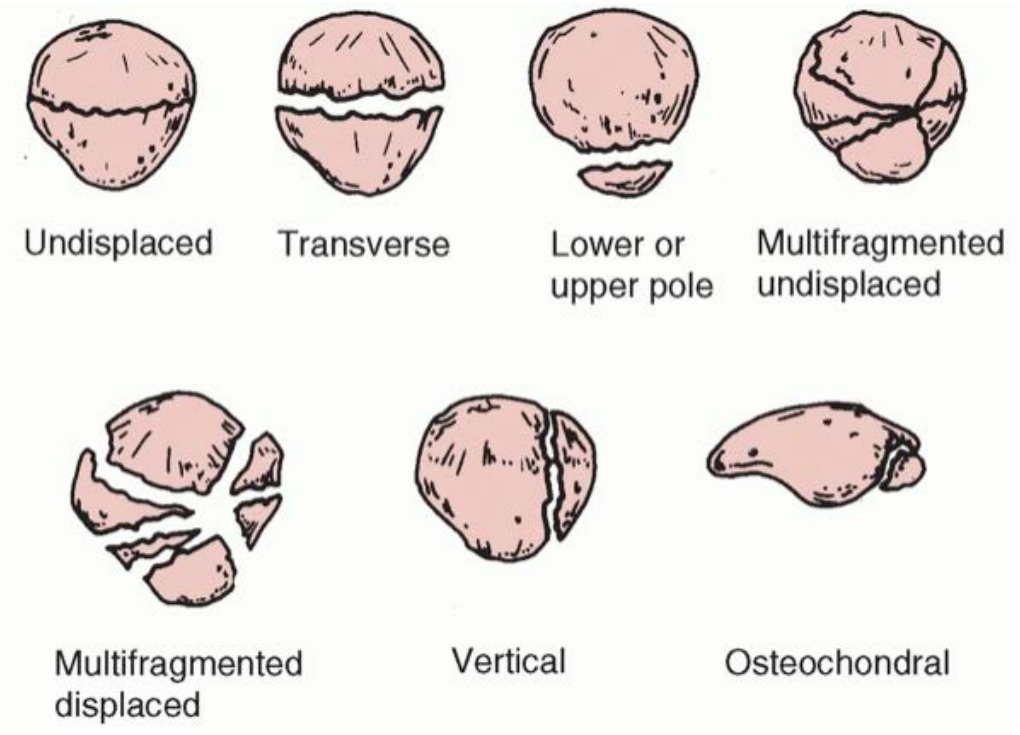
Position of knee	Contact surface of patella	Contact surface of femur	Function of patella
From full flexion to 135° of flexion	Medial and lateral facet (Superior part)	Medial and lateral femoral condyles	Linking - Transmission of torque from quadriceps muscle to proximal tibia
135° to 45° of flexion	Odd facet	Tibial surface of medial femoral condyle [29]	Linking - Transmission of torque from quadriceps muscle to proximal tibia
	Medial and lateral facet (Middle part)	Trochlea of femur	
45° of flexion to full extension	Medial and lateral facet (Inferior part)	Trochlea of femur	Displacement – tendon is displaced away from the centre of rotation and moment arm is increased

The displacement function of patella is most important in the range of 0^o to 45^o of flexion. Twice as much as force is required for the terminal 15^o of extension, as is required for range of movement from full flexion to 15^o of flexion [22]. The patello-femoral articular surface is subjected to very high stress due to the high torque generated by the extensor mechanism. Compressive forces equivalent to almost three to seven times the body weight have been noted during climbing and squatting [30]. This makes the patella-femoral joint to be subjected to highest level of stress compared to any other weight bearing joint in human body. This highlights the importance of restoration of the alignment of the articular surface to avoid the development of patella-femoral arthritis.

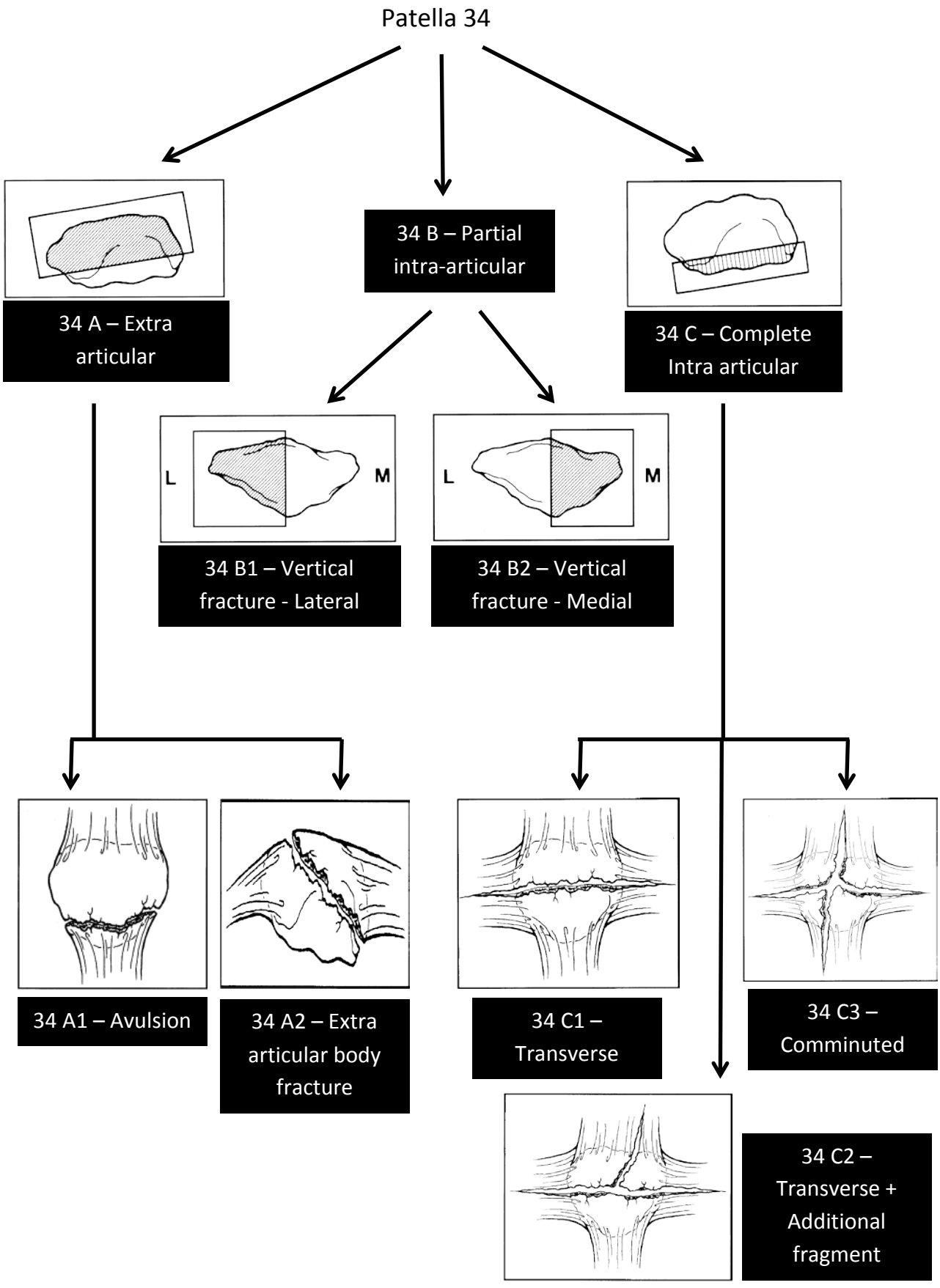
Classification

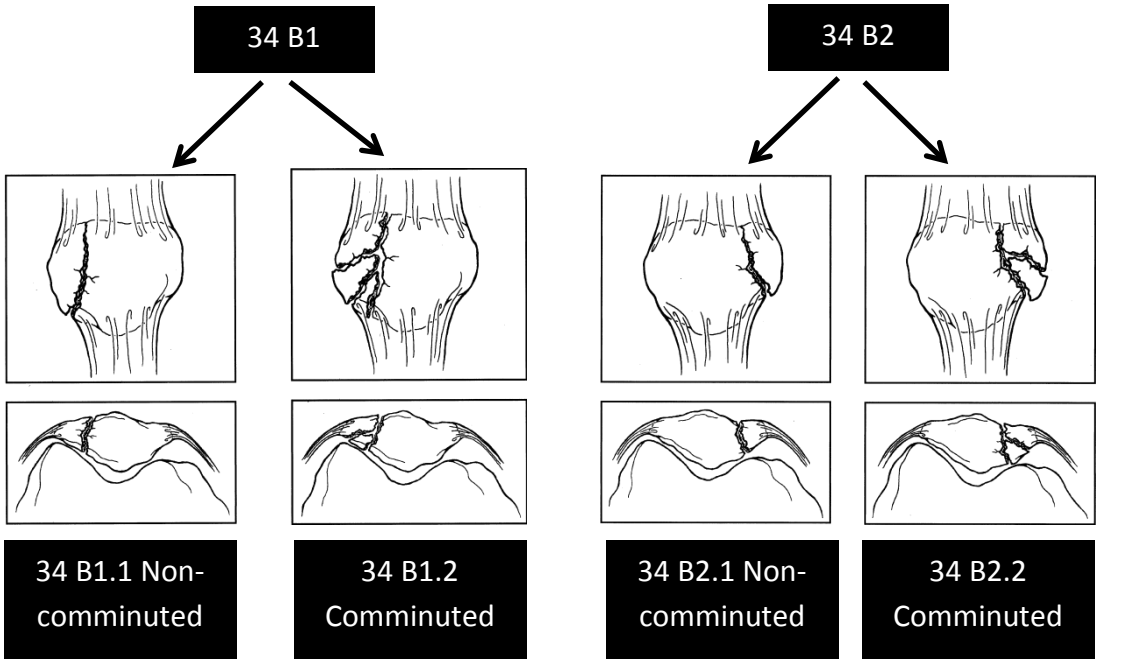
The commonly used classification system is the descriptive classification which is illustrated as follows.

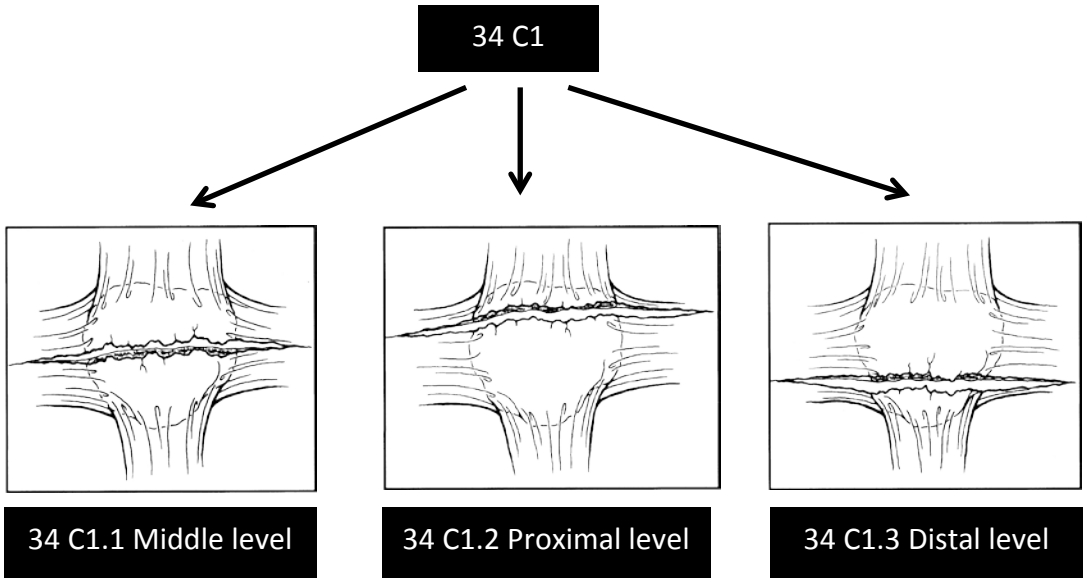


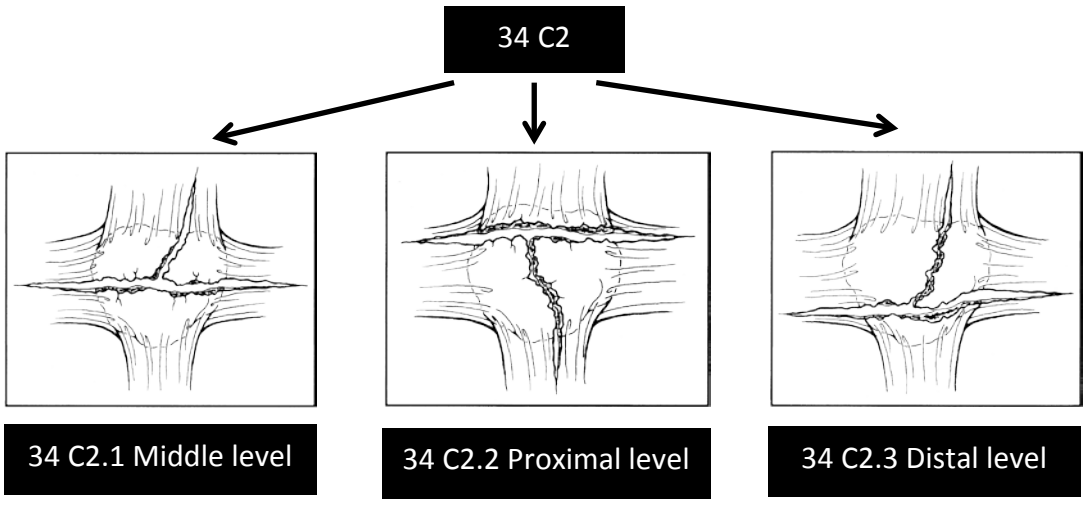


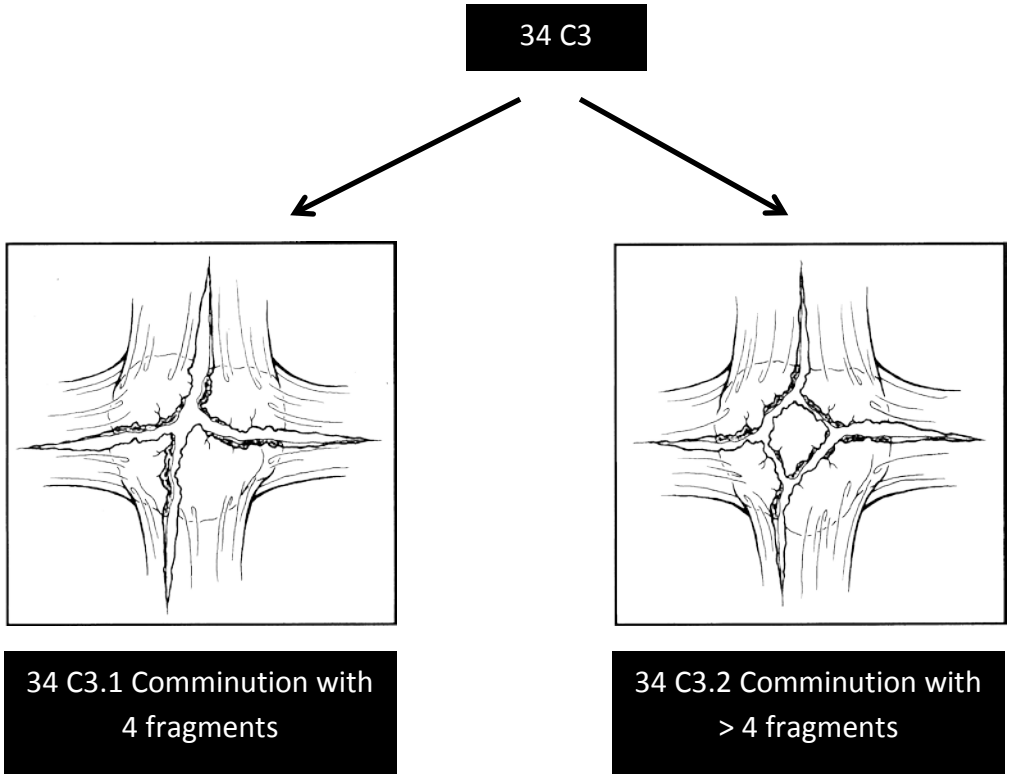
The AO classification for Patella fractures is illustrated as follows




34 B1
34 B2
34 B1.1 Non-comminuted
34 B1.2 Comminuted
34 B2.1 Non-comminuted
34 B2.2 Comminuted


34 C1
34 C1.1 Middle level
34 C1.2 Proximal level
34 C1.3 Distal level


34 C2
34 C2.1 Middle level
34 C2.2 Proximal level
34 C2.3 Distal level



The pattern of patella fractures that were included in this study were of the Displaced transverse type as per the descriptive classification, the AO classification for the same being 34C1.

Management options

Management of Patella fractures depends on the following important factors

1. Fracture classification
2. Findings on physical examination
3. Integrity of extensor mechanism
4. Age of patient
5. Bone quality
6. Patient expectation
7. Associated injuries

The treatment goals of Patella fracture management are

1. Restoration of articular congruity of patello-femoral joint
2. Functional integrity and strength of extensor mechanism
3. Restoration of the normal linking and displacing functions of the patella

As for any other fractures, Patellar fractures also have a wide variety of treatment options. Broadly classified into non-operative and operative, there are many techniques presently used for management of Patellar fracture.

I. **Non-operative treatment**: The indication or pre-requisites for this mode of treatment are
    1. < 3 mm of fragment separation
    2. < 2 mm of articular incongruity
    3. Intact extensor mechanism

The relative indications for non-operative management include comorbid conditions which make the patient unfit to undergo any surgical procedure and elderly patients with severe osteopenia. The above group of patients may be managed conservatively even in presence of gross displacement or articular incongruity.

The treatment protocol in this method of management, consists of immobilisation of the affected knee for a period of 4 to 6 weeks using extension brace or splinting. In cases of doubtful compliance from patient a long leg cylinder cast is advised, with special care to moulding at the knee and above the ankle to prevent loosening after oedema subsides. Range of motion exercises are begun after radiological evidence of fracture consolidation by callus. In order to prevent muscle wasting, straight leg raises and isometric quadriceps exercises are advised with the limb immobilised in cast. Different authors give varied opinion regarding weight bearing. Early partial weight bearing supported by DePalma [(31)], whereas Bohler and Bostrom [(18)] recommended pain tolerated crutch supported weight bearing. Pritchett et al. [(32)] had obtained good functional results without significant limitations in daily activities, with conservative management. Bostrom et al. [(18)] in a large series involving 422 patellar fractures with 219 minimally displaced fractures had obtained 98% excellent results in final follow up.

II. **Operative treatment :** The indications for operative treatment are as follows

1. > 3 mm of fragment separation
2. > 2 mm of articular incongruity
3. Damaged or disrupted extensor mechanism

The aim of the operative treatment is to obtain a stable fixation and a functional extensor mechanism that permits early range of movements and rehabilitation. The options broadly classified as internal fixation, partial patellectomy and total patellectomy.

IIa. Internal fixation:

The earlier options available were

- Cerclage wiring described by Berger in 1892 [33]
- Equatorial circumferential wiring described by Anderson [33]
- Intraosseous vertical wiring by Magnuson and Payr [34] [35]
- Screw fixation for longitudinal and transverse fractures [36] [37] [15]

The potential disadvantage of all these fixation techniques was risk of displacement and lack of fracture compression due to pull of Quadriceps muscle during extension and therefore delayed mobilisation. This disadvantage was answered by Tension Band wiring technique introduced by AO group [38]. The principle of Tension Band wiring being, conversion of the tensile forces exerted by Quadriceps pull on the anterior cortex of patella into compressive forces at the posterior cortex to aid in fracture healing. With knee flexion, the passive pressure exerted by femoral condyles on the posterior cortex of patella gives rise to the compression force.

Benjamin et al. on study comparing the strength of four fixation methods namely tension band wiring, modified tension band wiring with Kirschner wires, anterior longitudinal banding method of Lotke and Ecker, cerclage wiring – found out

that cerclage had the weakest strength and modified tension band wiring had the strongest fixation among these [39]. Burvant et al. found that anterior tension band wiring in combination with 3.5 mm or 4.5 mm screws was superior to the previous methods in terms of fixation strength [40]. Carpenter et al. in a cadaveric model compared modified tension band wiring, Interfragmentary lag screws using 4.5 mm cortical screws in parallel manner and 4.0 mm cannulated cancellous screws augmented with tension band wiring passed through screws and found out that fixation with cannulated screws augmented by tension band wiring had the highest load to failure [9]. Baran et al. using MRI in cadaveric knee model fixed with tension band wiring, advised placement of the wires as close to the bone as possible with minimal tendinous tissue interposition [13]. Scilaris et al. compared 1.0 mm wire and 1.0 mm braided cable for tension band wiring and found that braided cable permitted less fragment displacement during cyclical loading [41]. Schauwecker R [42] demonstrated better interfragmentary compression using twisting the wire loop at two different sites. John et al. demonstrated better stability, if the wire twists was placed at the corners of the figure of eight loop [14].

Open patellar fractures constitute an orthopaedic emergency which warrants immediate surgical debridement and internal fixation under appropriate antibiotic cover. The post op protocol depends on the type of internal fixation chosen that particular patient, age, physical demand, bone quality and the rigidity of the construct used to fix the patella. This may vary form immediate passive range of movements or delayed mobilisation of the operated knee. The decision regarding weight bearing walking also depends on above mentioned factors. The aim of non-operative or

operative treatment of patella fractures is to provide a functional extensor mechanism for pain free daily activities.

Materials & methods

The study was formally approved by the Hospital Ethical Committee. This prospective study involved 20 patients, who were admitted in the Department of Orthopaedics, Kilpauk Medical College Hospital during the period between February 2013 and November 2013. All patients had closed transverse fracture pattern of patella, which were fixed with arthroscopy assisted percutaneous osteosynthesis with cannulated cancellous screws and tension band wiring also known as the POMC (Percutaneous Osteosynthesis by Modified Carpenter's technique).

The inclusion criteria was

- Patients in the age group of above 15 years
- Patients presenting with patella fractures due to road traffic accident or fall at home or assault
- Fracture pattern with two fragment displaced middle third transverse type or AO Type 34C1

The exclusion criteria was

- Fractures with open wound or comminution of fracture.
- Fractures other than the pattern AO 34C1
- Patients with head injuries and who are comatose.
- Patients with risk of infections like on immune-suppressant drugs
- Patients with inherent immunodeficiency

- Patients with inflammatory musculoskeletal disorders like Rheumatoid arthritis, Ankylosing Spondylitis, Reiter's disease, Reactive Arthritis, Psoriatic arthritis.

All patients were admitted and initially managed with posterior tube splint using plaster of Paris to reduce pain. Patients were then investigated as follows

1. Radiological: Plain x-ray of the affected knee in true Antero-posterior, true lateral and axial or skyline view (if needed), to evaluate the pattern of fracture and to rule out any comminution
2. Complete hemogram
3. Renal function test
4. Bleeding time and clotting time
5. Screening for HIV, Hepatitis B & C, Syphilis
6. Chest X-ray and Electrocardiogram

All the above mentioned investigations were done to get pre-operative anaesthetic fitness. If the patient had any co-morbid illness like diabetes, hypertension, ischaemic heart disease etc. the opinion from the concerned specialist was obtained regarding surgical fitness for surgery.

Instruments used:

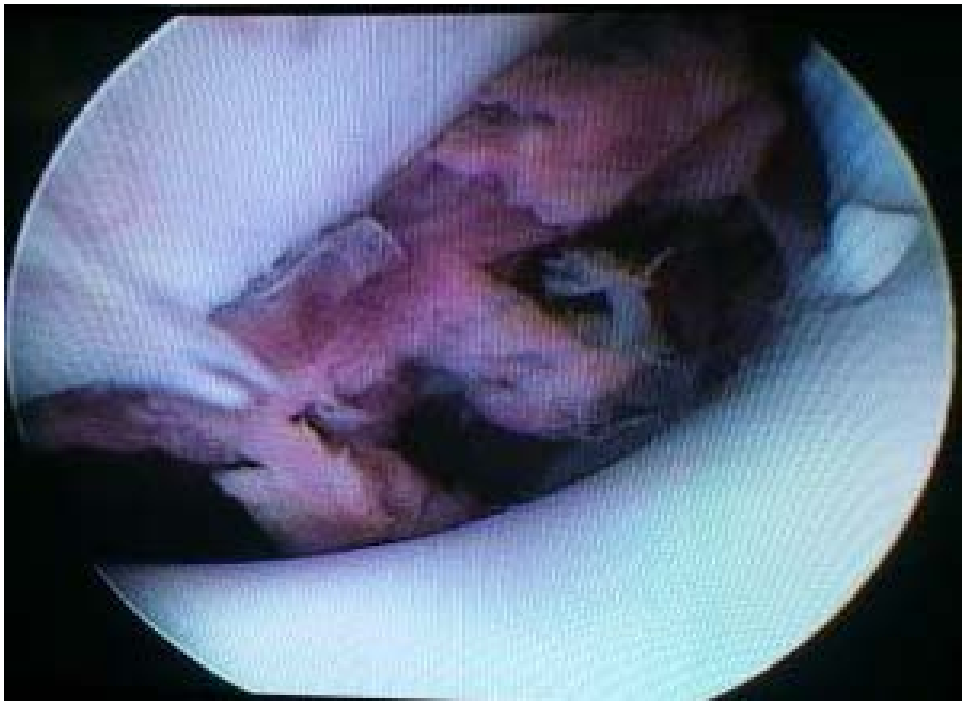
1. Diagnostic arthroscopy instrument system
2. 4.0 mm cannulated cancellous screw system
3. 18-G stainless steel wire
4. Pliers and wire cutters
5. C-arm fluoroscopy

Surgical technique: Percutaneous Osteosynthesis by Modified Carpenter's technique

All patients were operated under spinal anaesthesia. In supine position over a standard radiolucent fracture table, with pneumatic tourniquet applied over the

Patient position before and after draping

proximal thigh taking care not to entrap the Quadriceps muscle, patient was painted and draped. The tourniquet pressure was set at 100 mm of Hg higher than the systolic pressure of the patient. Using superolateral portal for knee arthroscopy the joint entered. The land marks for superolateral portal being a spot 2.5 cm superior to the superolateral corner of patella and just lateral to the quadriceps tendon. The joint evacuated of the hemarthrosis and is thoroughly washed of using 2 to 3 litres of normal saline to get a clear visual field. Joint inspection is done using 30^{o} arthroscope and the patello-femoral joint thoroughly examined. The articular surface of patella and femur inspected. The antero-medial portal is used to insert the probe for proper joint visualisation and when necessary the loose fragments are removed. The landmarks for antero-medial portal being 1 cm medial to the patellar tendon and 1 cm superior to the medial joint line. The scope is now removed along with the sleeve.

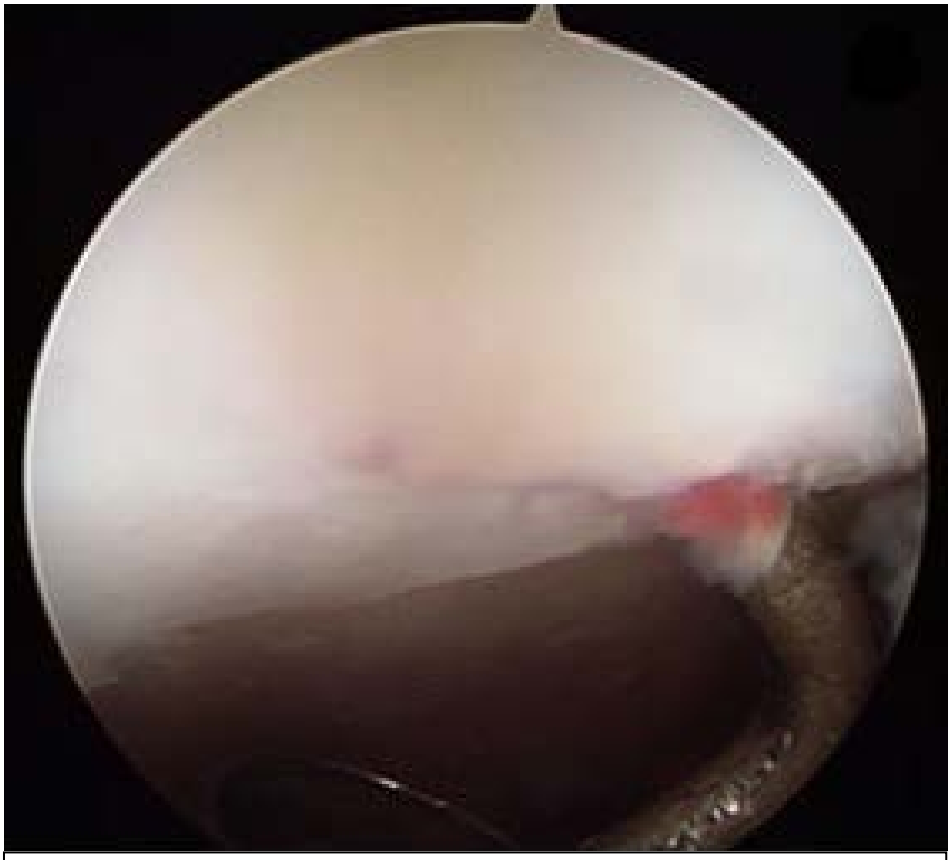


Arthroscopic inspection of joint showing cartilage fragments

Manual reduction: With the knee in full extension, the superior and inferior patellar fragments are reduced into approximation and held together using a pointed reduction

Arthroscopic picture before reduction of fracture

forceps applied across the long axis of patella hooking against the superior border and inferior pole. The articular congruity is checked using fluoroscopy. If not satisfactory the procedure repeated. If the fragments are difficult to handle with fingers they are individually held with two pointed reduction forceps, manipulated into reduction and held together by a third pointed reduction forceps. If the reduction is satisfactory under fluoroscopy, the joint is again inspected arthroscopically. The reduction of the fractured fragments and the articular surface alignment are checked by arthroscopy and necessary adjustments made. Satisfactory reduction is the aim of this manoeuvre.



Arthroscopic picture of after reduction of fracture

Percutaneous screw fixation: This consists of the following steps in order

1. The knee is maintained in a position of 15^{o} to 20^{o} of flexion by placing a sand bag underneath the popliteal fossa and the fracture site is checked for any displacement with fluoroscopy. If found displaced it is again reduced. But usually this did not happen as the fracture was held firmly by the pointed reduction forceps.
2. Adjustments are made to get a true lateral projection in the fluoroscopy projection.
3. The 1.25mm guide wire for the 4.0 mm cannulated screw is inserted antegrade, using a stab incision, distanced as necessary from the superior border of patella,

oriented along the line through the junction of lateral third and medial two thirds of patella.

4. The wire is brought out through a second stab incision inferior to the inferior border of patella distanced as necessary from it.
5. The position is checked under fluoroscopy so that the guide wired is at minimum distance of 5 mm from the anterior surface but not into the posterior half of the patellar thickness.
6. If satisfactory the second guide wire is inserted in the same manner as described above along the line through the medial third and lateral two third junctions.
7. The two guide wires are placed 1.5 to 2 cms apart.

Position of two parallel guide wires after fracture reduction

Position of two parallel guide wires and fluoroscopic image showing articular surface alignment

8. The length of the screw is calculated by subtracting the length of guide wire projecting form either ends of patella. The actual length of screw that would be used is 5 mm shorter than this length, to avoid the inferior end from penetrating out of the inferior end of patella, as it would cause a stress riser in the wire applied for tension band wiring.
9. After drilling using 2.7 mm cannulated drill bit, the measured size 4.0 mm cannulated cancellous screw with short threads inserted antegrade along with washer and tightened to provide the compression by lag screw principle.

Drilling using 2.7 mm cannulated drill bit

Insertion of 4.0 mm cannulated cancellous screw over guide wire

Insertion of second cannulated cancellous screw

Fluoroscopy image showing articular surface alignment

10. The articular surface reduction is again confirmed by fluoroscopy and arthroscopy.
11. Stainless steel wire of 18 G size and of length 30 cm is introduced antegrade through both screws to exit through the inferior stab incision.
12. Using a long curved artery forceps and entering through one superior stab incision, the forceps is advanced in the direction of the inferior stab incision of the other screw, by subcutaneous tunnelling.
13. The jaws of forceps is exited through the inferior stab incision of the other screw and the inferior tip of the stainless steel wire of the other screw is bent, fed into the jaws of the forceps and retracted to come out of the proximal stab incision of the corresponding screw.
14. The above procedure is repeated for the other screw, leaving the two free ends of both stainless steel wires exiting through the proximal stab incision.

Insertion of 18 G stainless steel wire and simultaneous removal of guide wire

Sub-cutaneous tunnelling to grab the inferior end of stainless steel wire of the other screw

Completion of single loop of stainless wire

Completion of double loop of stainless wire

Simultaneous tightening of two loops for tension band wiring

Completion of tension band wiring

15. Using two pliers the wires are twisted into two knots with equal tension on both ends, thus completing the figure of 8 tension band wiring in horizontal orientation.
16. The articular surface reduction is checked again using fluoroscopy and arthroscopy and checked through a flexion arc of 0^o – 90^o.
17. The extra wires are cut, the knots bent and buried underneath the subcutaneous tissues.
18. The stab skin incision is closed with 2-0 Ethilon.
19. Sterile dressing done and knee brace applied.

The above surgical steps complete the Percutaneous Osteosynthesis by Modified Carpenter's technique.

Wires are cut, bent and buried. Skin closed with Ethilon

Post – Operative protocol:

- ☞ For the immediate post-operative period the knee was protected with knee brace
- ☞ Passive range of movements was started as soon as the patient tolerated pain usually in the first or second post-operative day.
- ☞ Full weight bearing with knee protected in knee brace was started from the second post-operative day. **Brace was advised only during weight bearing**.
- ☞ Patient was discharged on the fifth post-operative day

- ☞ Active knee range of movement exercises was started after suture removal usually 2nd week

- ☞ Knee Brace discarded after completion of 8 weeks and patient advised full weight bearing with restriction of strenuous works like squatting, sitting crossed legged.
- ☞ Squatting and sitting crossed legged were permitted after clinical and radiological evidence of union.
- ☞ Patient was reviewed every two weeks and assessed clinically
- ☞ Radiological assessment was done by taking X-rays after completion of 3-4 weeks and 12 weeks.
- ☞ Patient was followed up every month after completion of 12 weeks until completion of 6 months
- ☞ Patient was subjectively assessed using the Lysholm knee score on 3 occasions namely 3-4 weeks, 12 weeks and 6 months
- ☞ Any incidences of infection, loss of reduction, wound complication, unbearable pain, difficulty weight bearing were noted.
- ☞ Radiological union was defined as at least 80% bridging of the fracture site by bone on the lateral view X-ray.
- ☞ Clinical union was defined as absence of pain and tenderness at the fracture site.
- ☞ The knee range of movement at the completion of 6 months was clinically assessed using goniometer.

Documentation:

The hospital inpatient records, operative notes of the cases were reviewed thoroughly. The time of surgery since injury, associated injuries and co-morbid

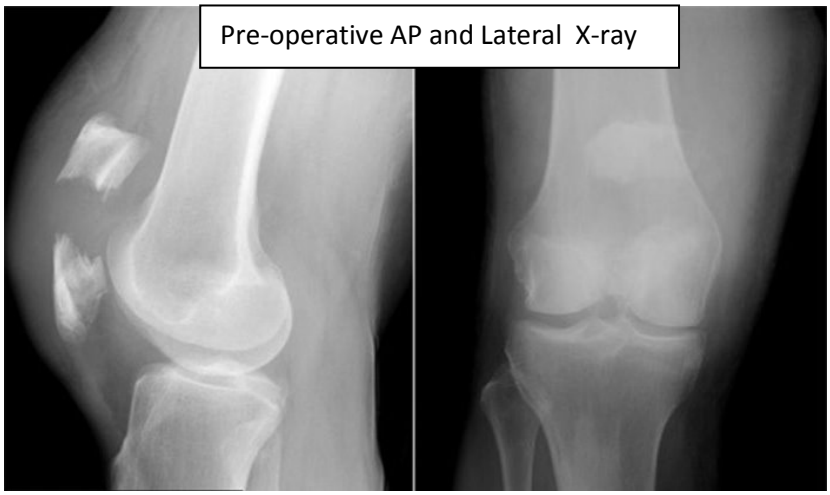
conditions, fracture gap, operative time, post-operative rehabilitation records were thoroughly analysed. Follow-up records were analysed for occurrence of any complications, time taken for fracture union, any requirement for re-surgery. Subjective analysis using Lysholm knee scoring system and objective assessment using clinical examination including pain free range of movements, followed by radiological assessment in standard Antero-posterior and lateral projection.

Case reports

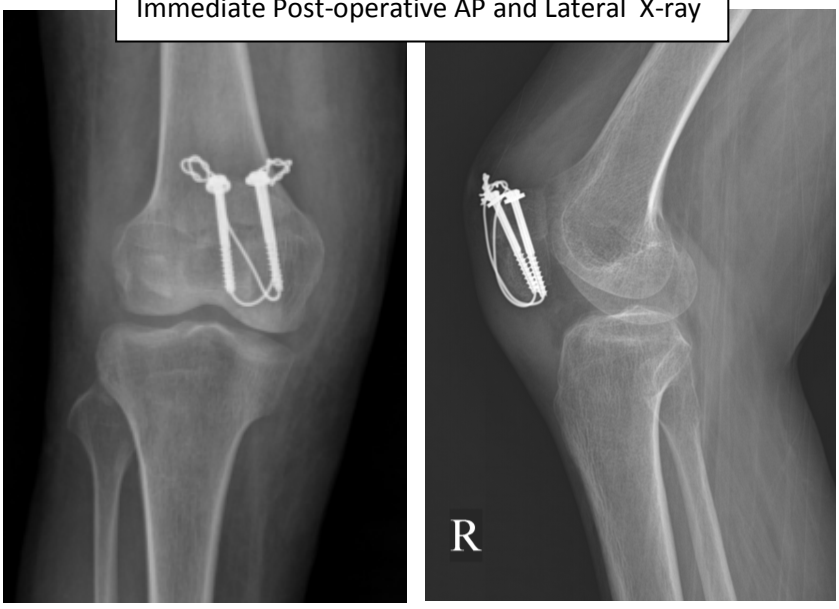
Case 1:

55 year old female Mrs.K was admitted to hospital with alleged history of self-fall due to slip over a wet floor and complaining of pain over the Right Knee. Patient was diagnosed to have a Mid-transverse fracture of patella (34C1.1), closed injury with no co-morbid illness. The patient was operated on the next day following admission.

Pre-operative AP and Lateral X-ray

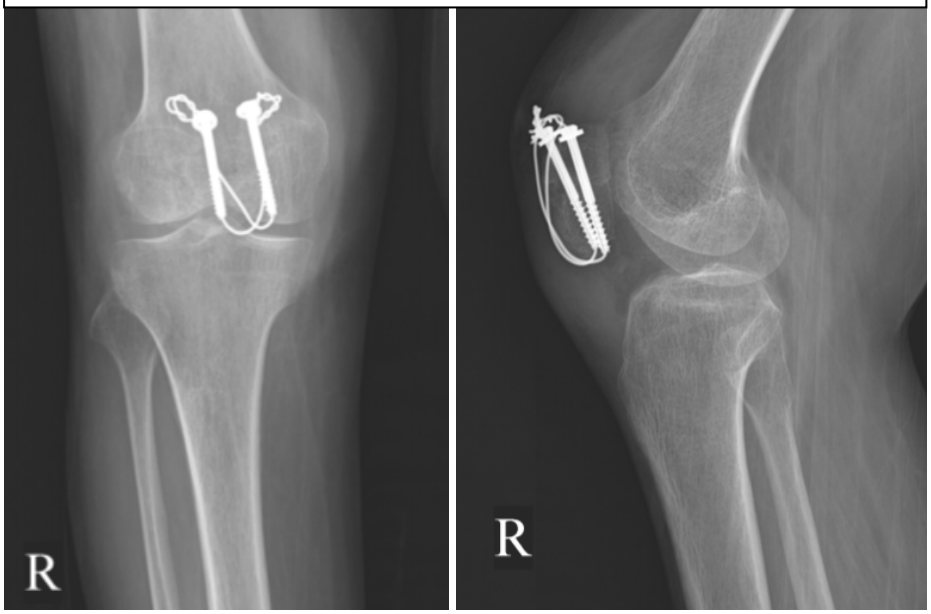


Immediate Post-operative AP and Lateral X-ray

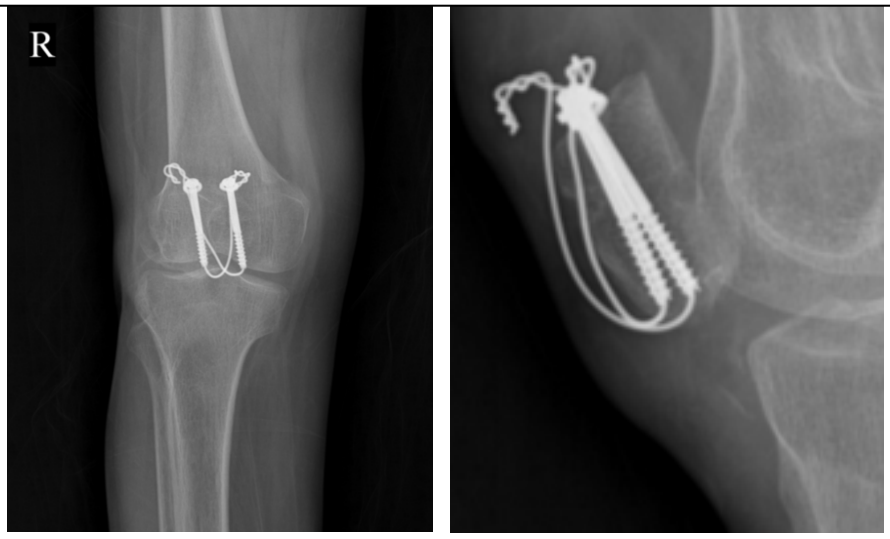


The patient had a pre-operative fracture gap of 20 mm that was well reduced and fixed with good compression. Routine post-operative protocol was followed.

12 weeks Post-operative AP and Lateral X-ray showing fracture union



9 months Post-operative AP and Lateral X-ray bridging trabecular bone



This patient had the last follow up at completion of 10 months and is presently ambulant without any symptoms.




Clinical photographs at the time of 10th month follow up showing absent extensor lag, good flexion. The patient was able to sit on the floor in a cross legged position and squat

Case 2:

65 year old female Mrs.S had a self-fall at home and sustained injury to left knee. Patient presented to hospital with pain and swelling over the left knee and difficulty walking. After clinical and radiological examination patient was diagnosed to have displaced mid transverse fracture of the left patella and was taken up for surgery on the next day following injury.

Pre-operative AP and Lateral X-ray

Immediate Post-operative AP and Lateral X-ray

The fracture gap was 5 mm pre-operatively and post-op gap was <1mm. Patient was managed by routine post-operative protocol and followed up to 6 months post-operatively. The fracture united at 14 weeks post-op.

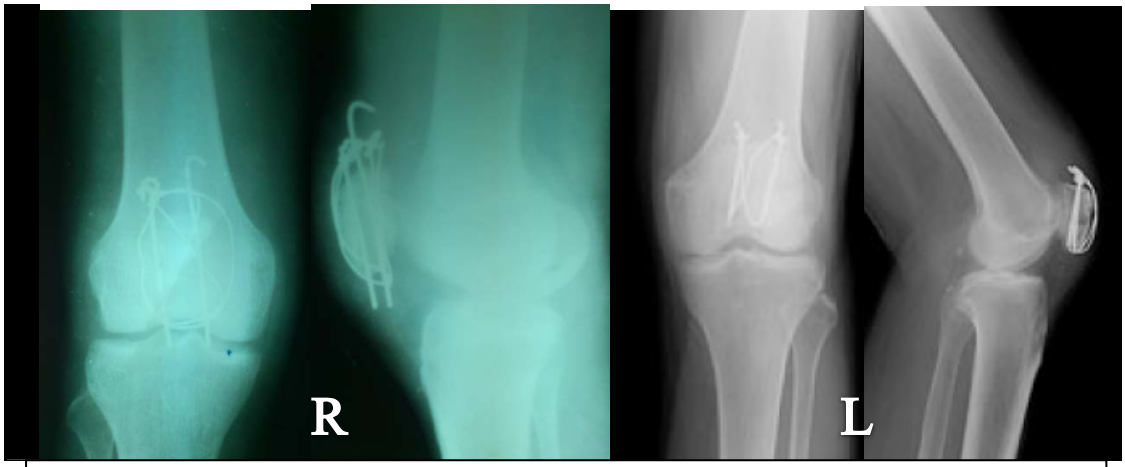
Clinical photographs after 6 months follow up showing good range of movements of knee with no extensor lag

Case 3:

21 year old Mr.N presented to hospital with alleged history of Road traffic accident and sustained injury to both knees. Mechanism of injury was head on collision between two wheeler and four wheeler, patient who was the pillion rider was thrown off the vehicle and landed on the ground with both knees hitting the road. Right knee had Grade III A compound fracture of patella with displaced transverse pattern involving the proximal third and middle third junction (34C1.2). Left knee had closed fracture patella displaced transverse pattern involving the middle third level (34C1.1).

Pre-operative AP and Lateral X-ray of both knees

The patient was initially managed with thorough wound wash and debridement of the right knee with bilateral posterior slab on day of admission. The patient was operated the next day. Both knees were operated on the same sitting. Right knee was managed by Open reduction extending the lacerated wound and internal fixation with Modified tension band wiring supplemented with cerclage wiring. Left knee was managed by Percutaneous Osteosynthesis using Modified Carpenter's technique.



Post-operative AP and Lateral X-ray showing Right knee operated by ORIF with Modified Tension Band Wiring and Cerclage wiring and left knee operated by percutaneous osteosynthesis by Modified Carpenter's technique

The patient was followed up till 7 months post-op. Both patellas united well without and complications. There was no infection or wound complication of both sides. The patient had no extensor lag on both sides. The advantage of the POMC technique being less invasive and functionally comparable is illustrated in the clinical picture.

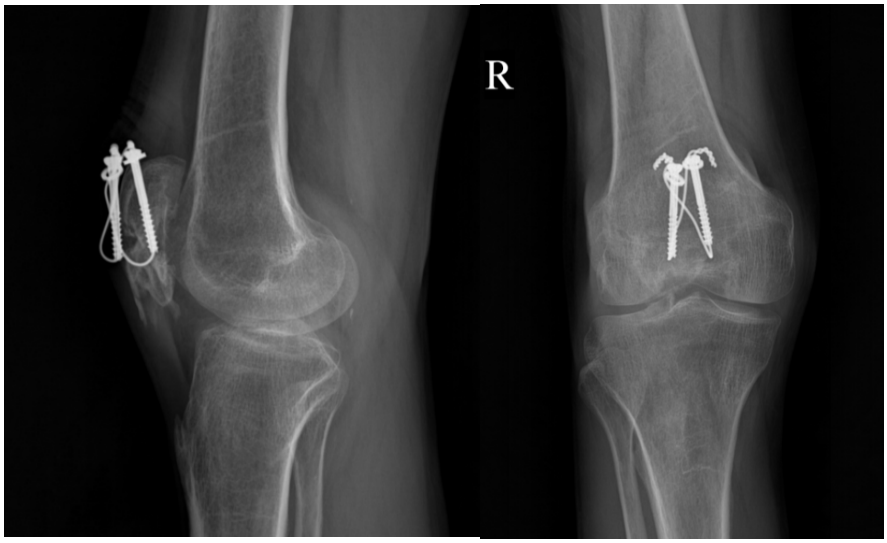
7th month post-op follow up Clinical picture showing large central scar on the right side compared with small stab incisions on the left side. There was no extensor lag on both sides.

Clinical photo showing no extensor lag on active extension and good range of knee flexion

Complications

Case 1**:** Hard ware irritation

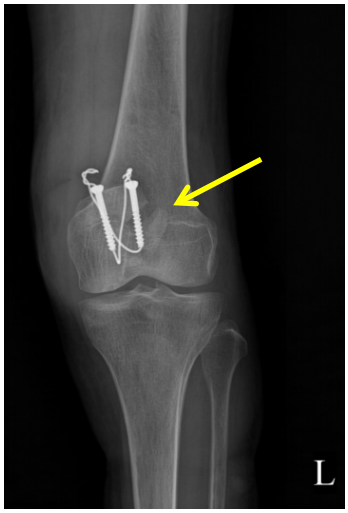
Mr.L 50/M operated for transverse fracture pattern of right patella presented 6 months post-op with complaints of pain and prominent hardware over the right patellar region. On palpation the lateral screw was palpated subcutaneously and his X-ray showed the screw had breached the anterior cortex of patella and was causing the symptom.



The fracture had united at the time of presentation. Therefore implant exit was done following which the patient was symptom free. He had painless range of movement 0^{o}-130^{o}.

Case 2: Re-fracture after repeated fall

Mrs.S 50/F was operated for transverse fracture pattern using POMC technique. During the second post-operative week, patient had a repeat fall with injury to the same knee and presented with aggravated pain and swelling. X-ray showed additional vertical split of the infero-lateral quadrant.

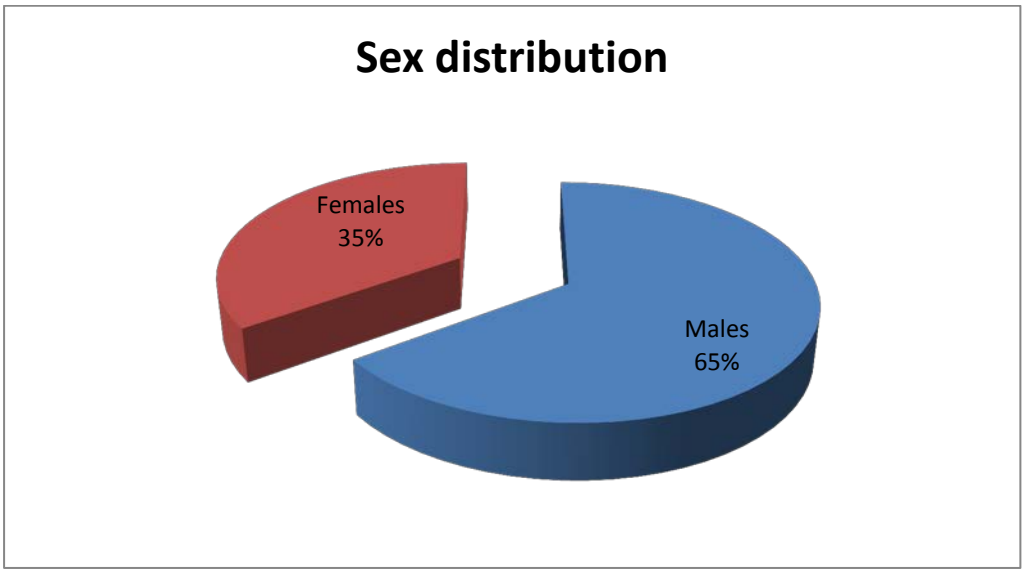


The patient was taken up for re-surgery and Open reduction and internal fixation using cannulated cancellous screws supplemented with tension band wiring through the screw and cerclage wiring was done. The fracture united uneventfully.

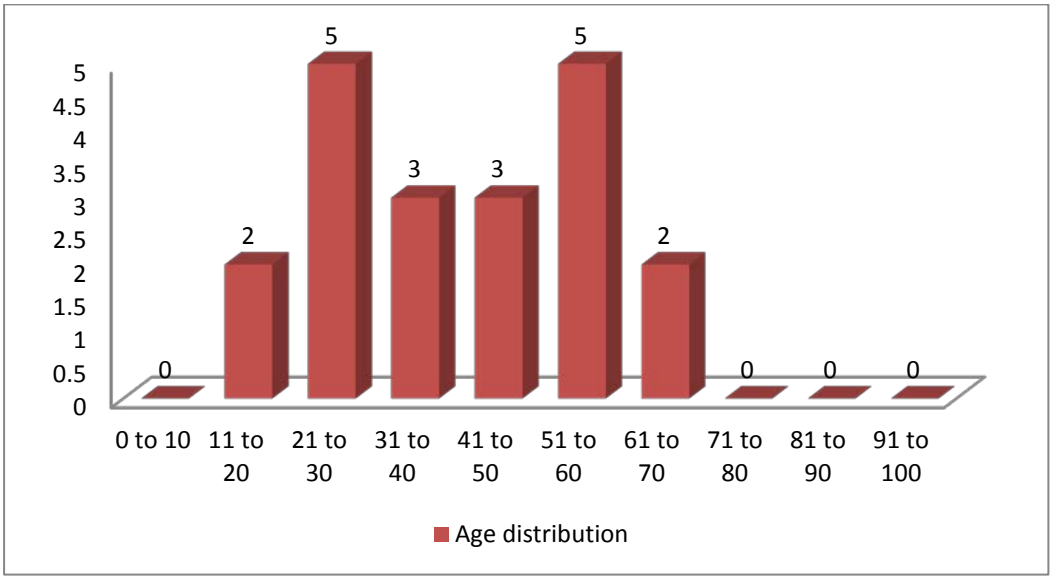
Observations

The patient demographics involved in the study is as follows.

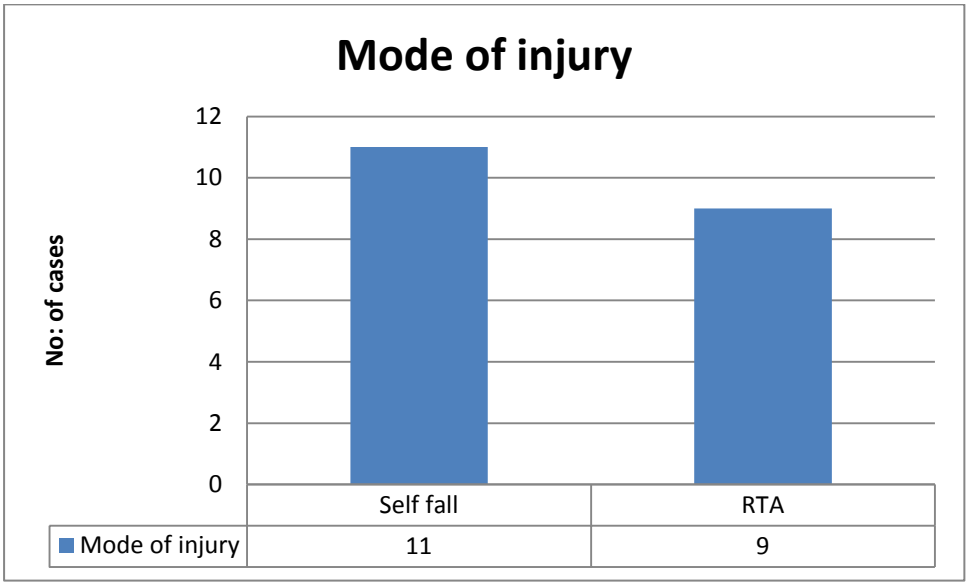
Among the total of 20 patients there were 13 males and 7 females with a ratio of 1.8:1 with clear male predominance.



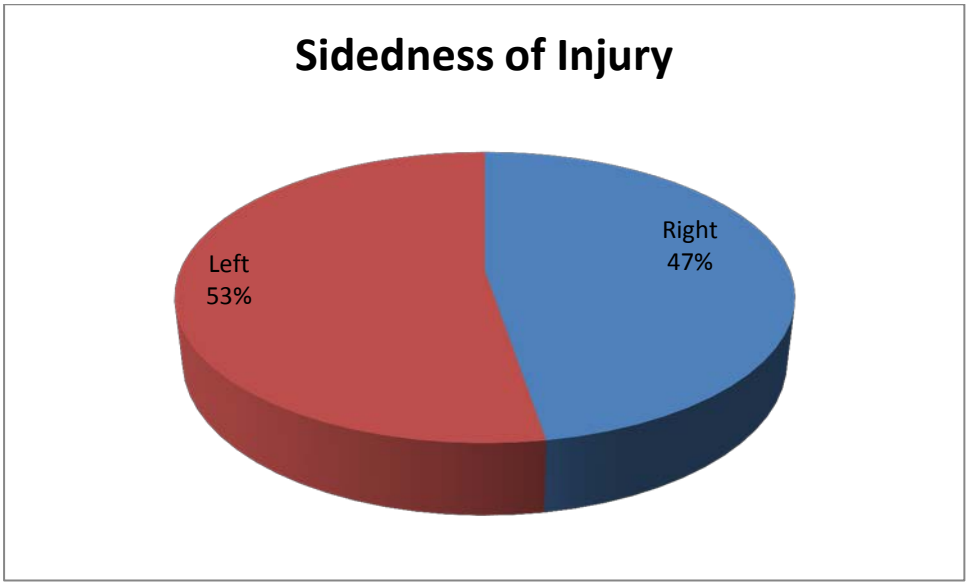
The age distribution had a bimodal presentation with two peaks in the third and sixth decade.



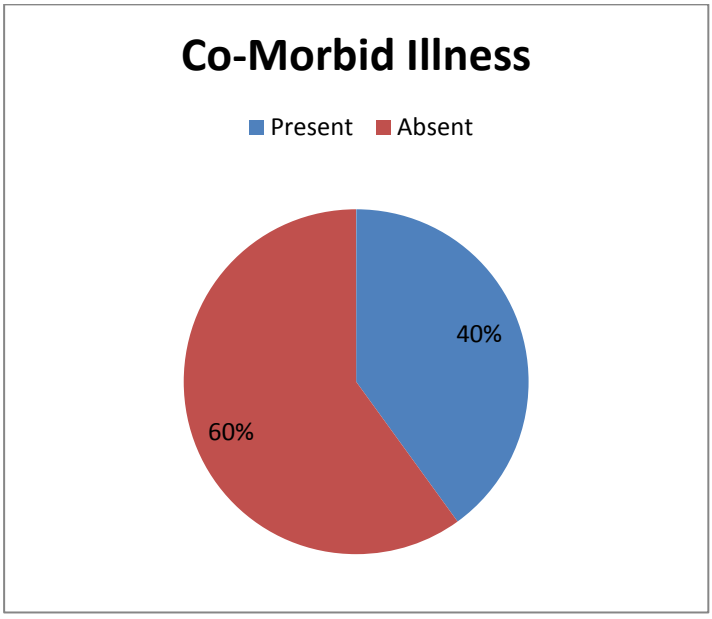
The most common mechanism of injury, being self-fall and the other being road traffic accident.

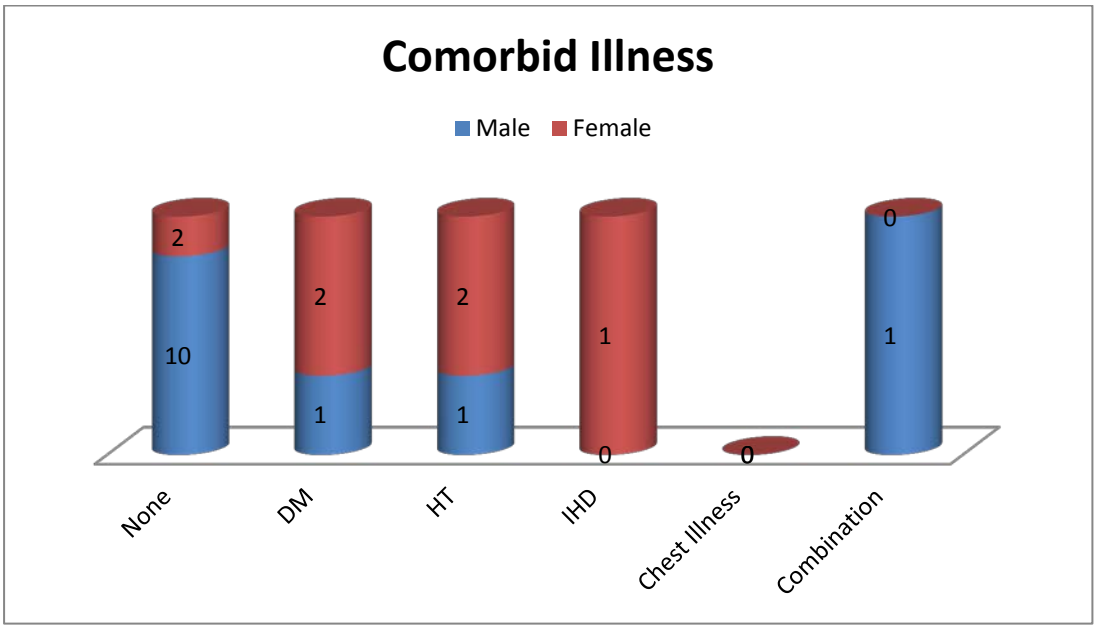


The sidedness was marginally towards the left side patella.



About 40% of the involved population had an associated co-morbid illness with diabetes mellitus and hypertension predominating the scenario.





Obviously the younger population did not show any co-morbid illness, whereas the aged population showed the above pattern with one patient having diabetes mellitus, hypertension and ischemic heart disease simultaneously.

Two cases had associated injuries at the time of presentation which were

1. Closed fracture of left distal radius – extra articular along with ipsilateral patella fracture
2. Closed fracture of right distal radius – extra articular with ipsilateral patella fracture

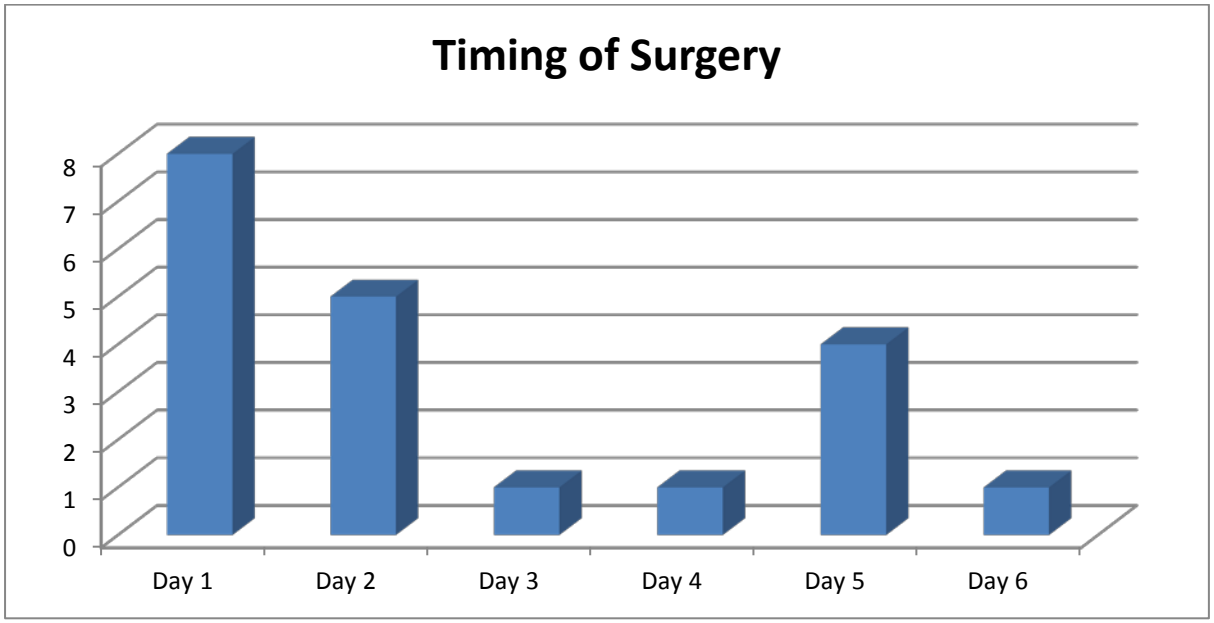
Both above cases were treated conservatively with closed manual reduction and splinting for distal radius fracture and POMC technique for patella.

One case presented with bilateral patella fracture with right side Grade III A open fracture of patella and closed fracture of left patella. The right patella was fixed by Open reduction and internal fixation with Modified tension band wiring and cerclage wiring while the left side was fixed by using the POMC technique.

Timing of surgery:

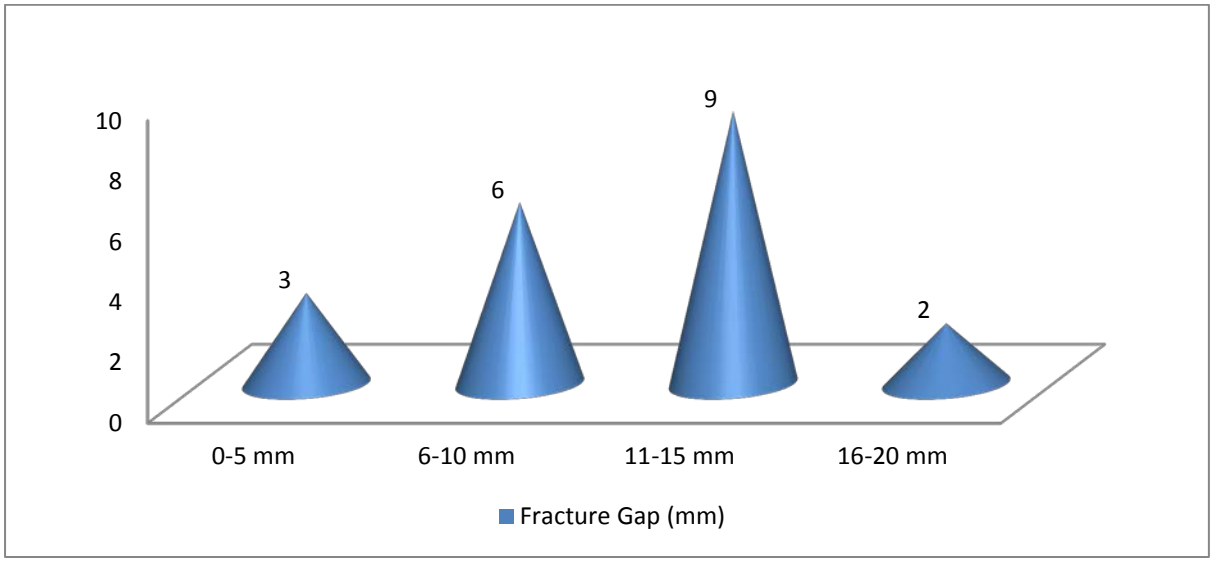
Majority of the cases were operated the day following the injury. But the cases with co-morbid illness had a delay as they had to be medically fit to undergo the procedure. The mean duration of gap between injury and surgery was 2.55 days, the minimum being 1 day and the maximum being 6 days. Patients with uncontrolled diabetes had to be put under Insulin regime as per Diabetologist opinion and fitness obtained after glycemic control. All patients with age above 40 years and those with previous history

of Ischemic heart disease were subjected to echocardiography and cardiologist opinion obtained regarding fitness for the procedure.



Fracture Gap:

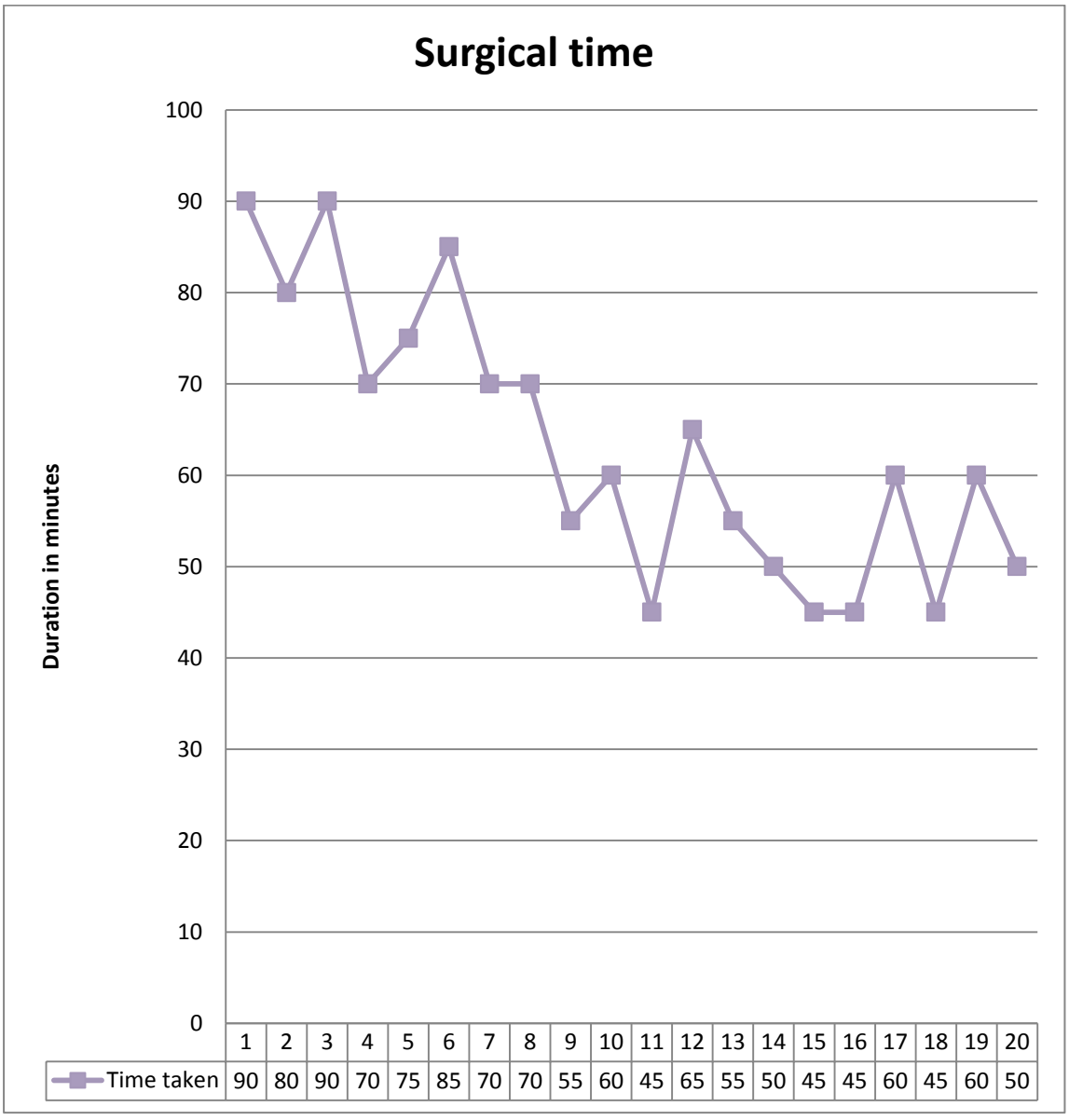
The mean separation of the fracture fragments was 11.55 mm with minimum being 4 mm and maximum being 20 mm. The maximum number of cases was in the range of 11 – 15 mm.



All cases had a post-operative measured fracture gap of 0 – 1 mm with good articular surface alignment. There was no case of articular surface mal-alignment in this series.

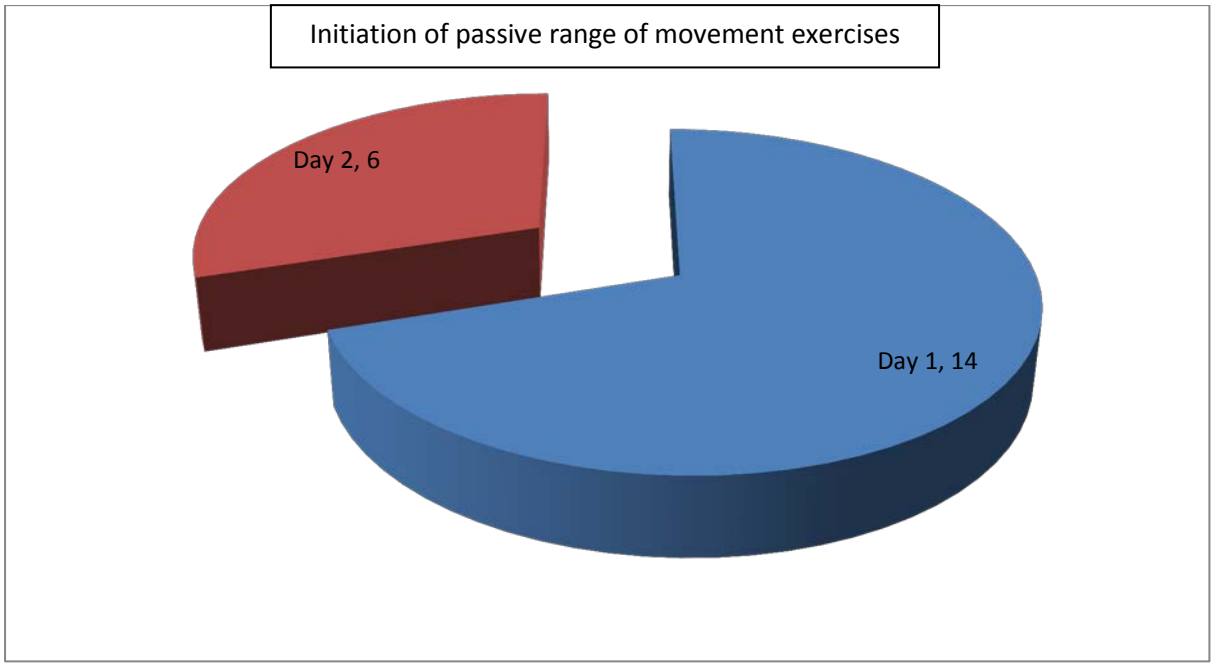
Surgical time:

The average time taken for the surgical procedure is 63 minutes, the shortest time being 45 minutes and the longest duration being 90 minutes. It was observed that as experienced was gained in sub-sequent cases the operating time gradually declined.

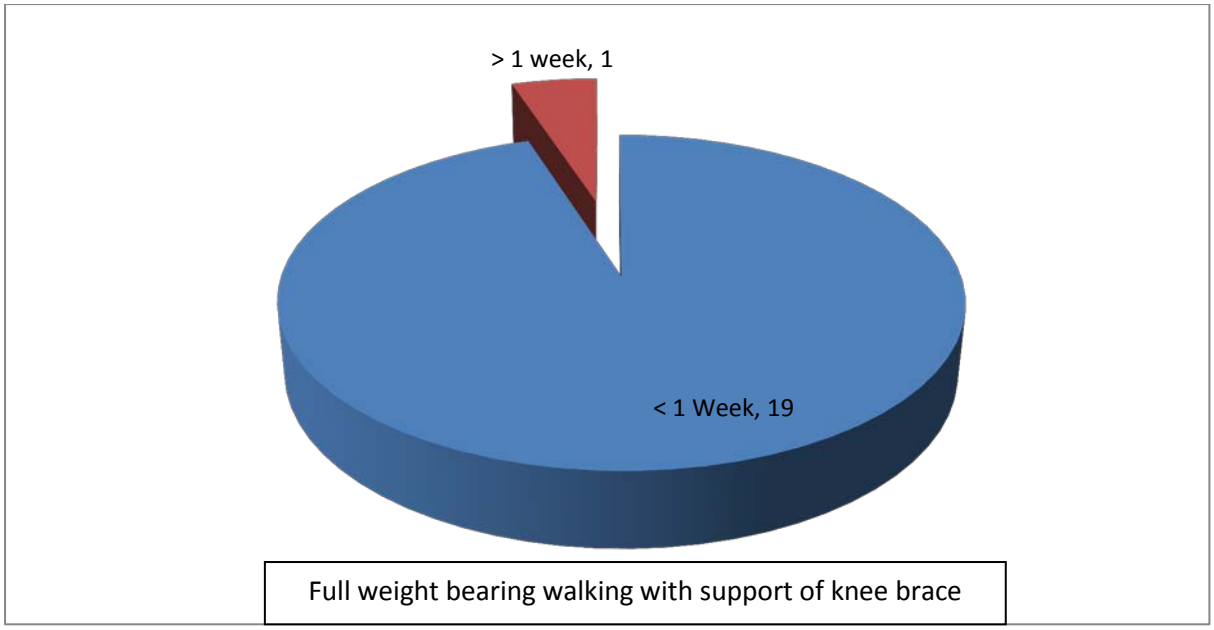


Mobilisation:

Pain tolerated passive range of movements were started on the first post-operative day in majority of cases (14 in number). The remaining cases were mobilised on the second day.



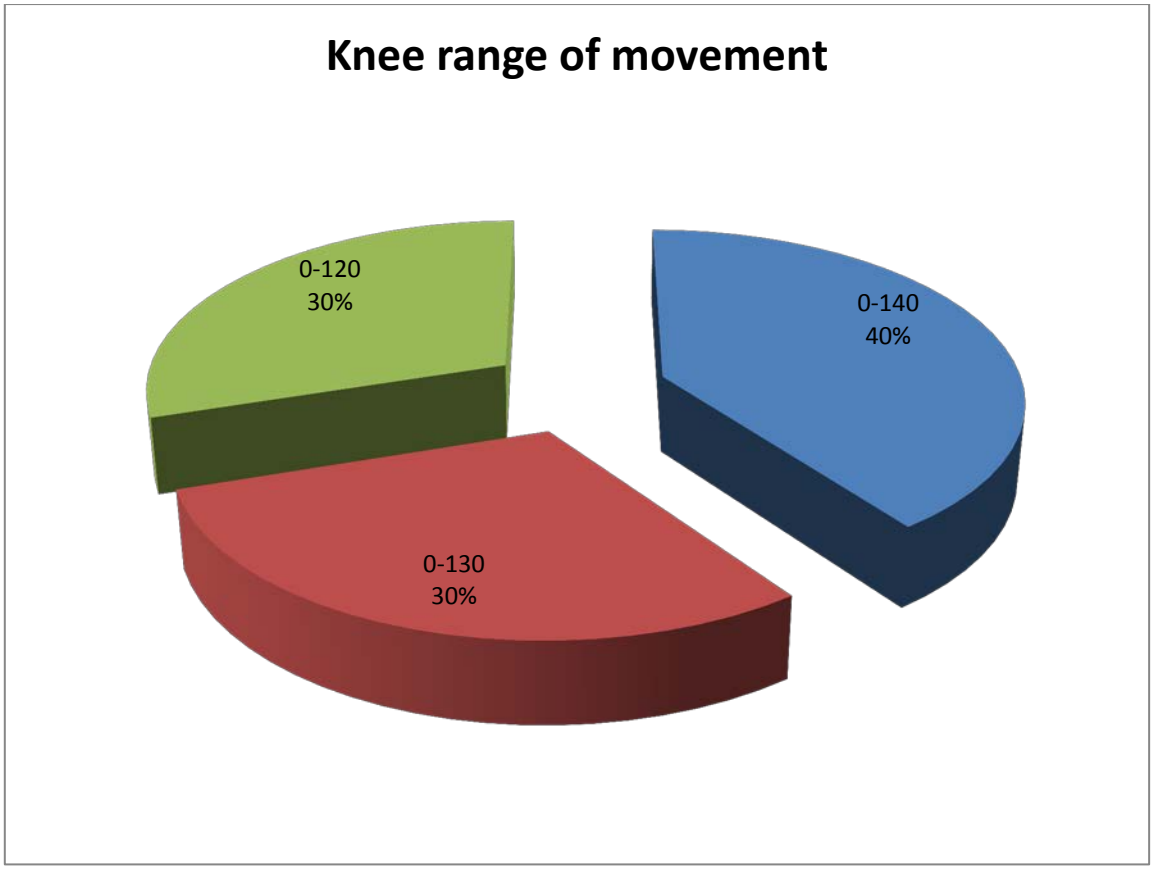
The average duration post-surgery for the patients to start full weight bearing with support of knee brace was 3.05 days, with the minimum being 2 days and the maximum being 12 days. The maximum time was for the case with bilateral fracture and the cases with other associated injuries also were weight bearing later, when compared to majority of cases who started bearing weight on the second or third post-operative day. Except for one all cases were walking with full weight bearing within the first week.



Active range of movement exercises were started after suture removal in all cases, which was usually around 2nd week. Knee brace was discarded after completion of 8 weeks.

Range of movements:

The average range of movements after radiological and clinical union of the fractured patella was a flexion arc with 0 - 131° with a minimum of 120° and a maximum of 140°. All patients resumed normal work by 12-14 weeks duration.



There was no incidence of extensor lag. Also there was no incidence of quadriceps wasting which was assessed objectively by comparing with the opposite side and also by measuring the muscle bulk on both thighs.

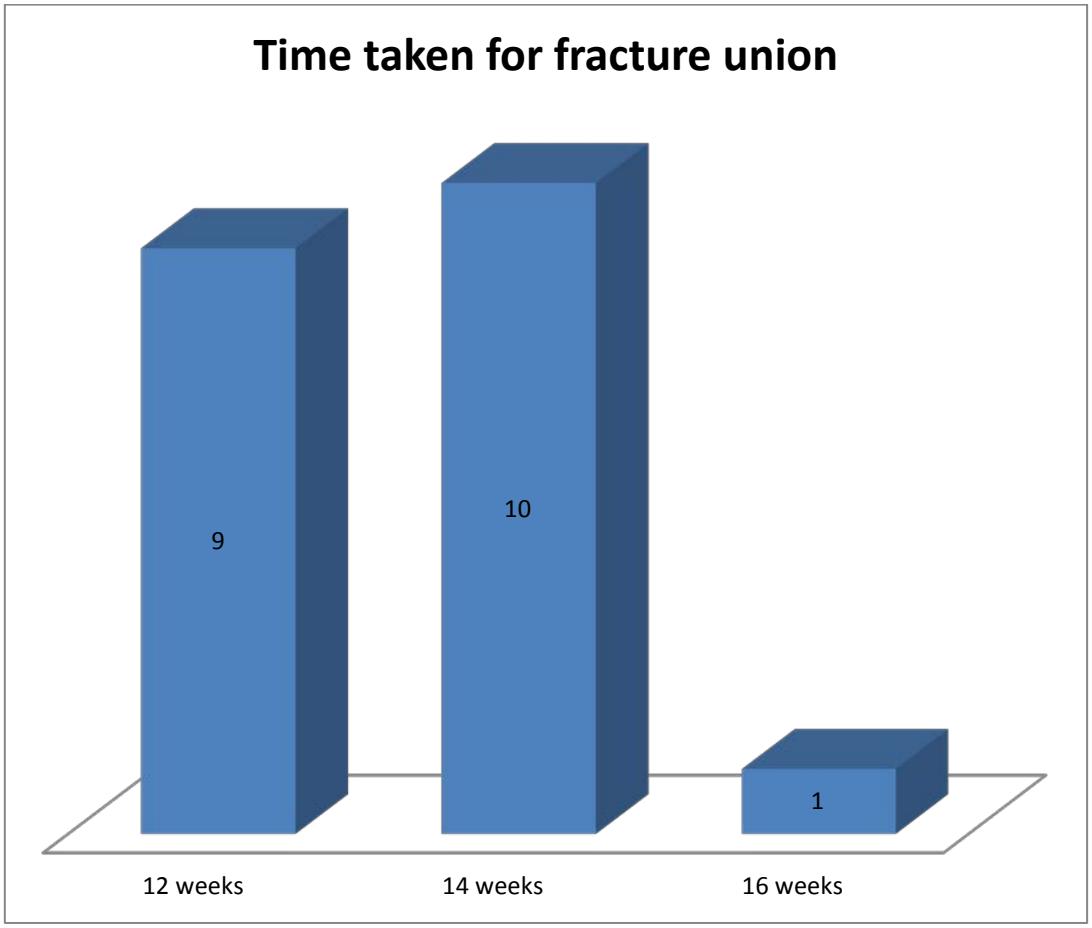
Infection rate:

There was no incidence of superficial or deep infection post-operatively until the last follow-up.

Time for fracture union:

The average time taken for clinical and radiological union of fracture patella was 13.2 weeks post-operatively, with a minimum of 12 weeks and maximum of 16 weeks. The criterion for radiological union was at least 80% bridging of the fracture

site by bony trabeculae. The criterion for clinical union was absence of pain and tenderness at the fracture site to passive manipulation.

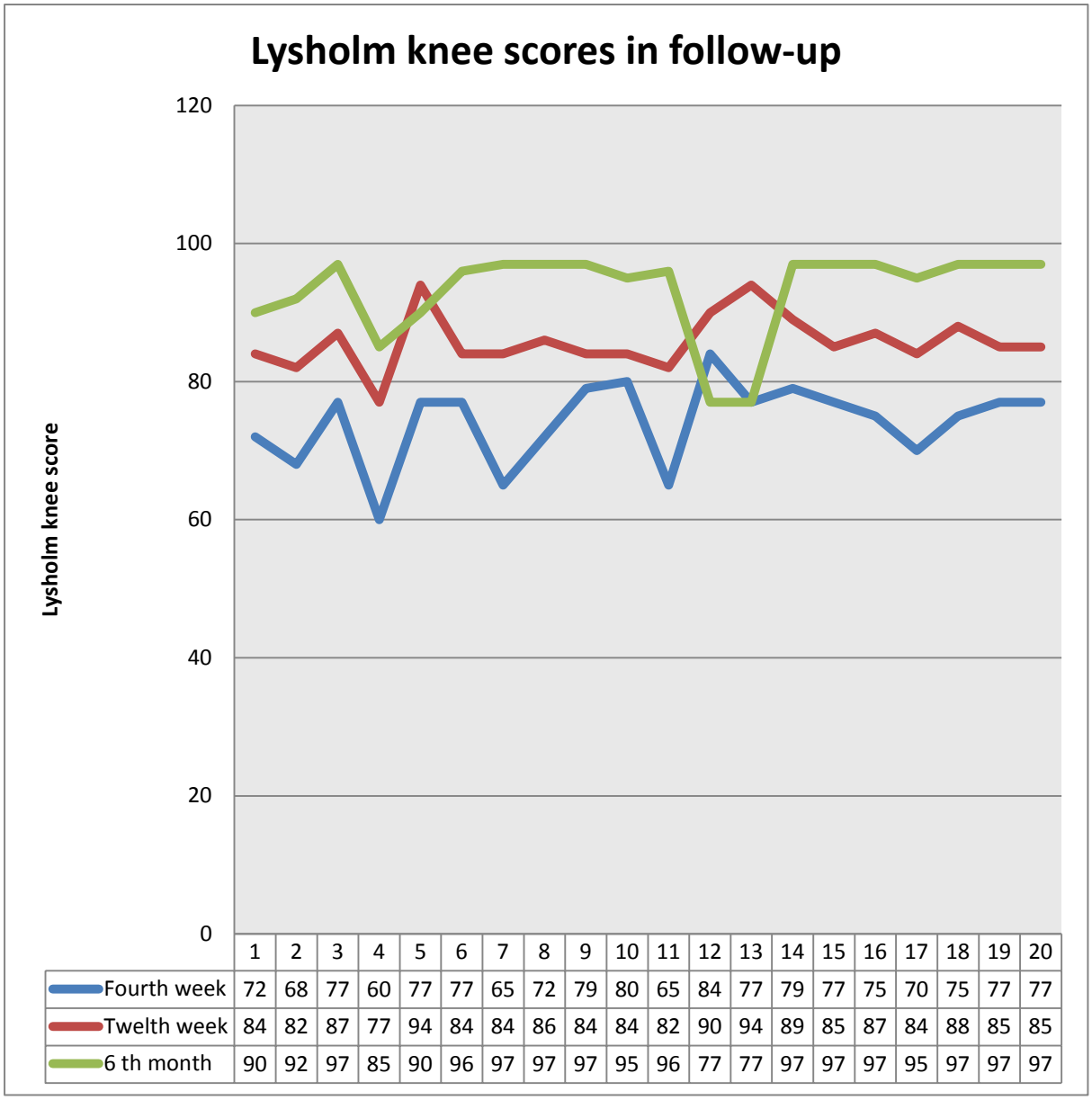


Subjective assessment of outcome:

This was carried by asking the patient to fill up the Lysholm knee scoring proforma which is enclosed in the appendix. The individual patient was given the task to be completed on fourth week, twelfth week and 6th month post-operatively. A steady improvement in the score was observed except in the cases which developed complications as listed above.

The grading of the Lysholm knee scoring system is as follows -

Score Value (Max 100)	Grading
< 65	Poor
65 – 83	Fair
84 – 90	Good
> 90	Excellent



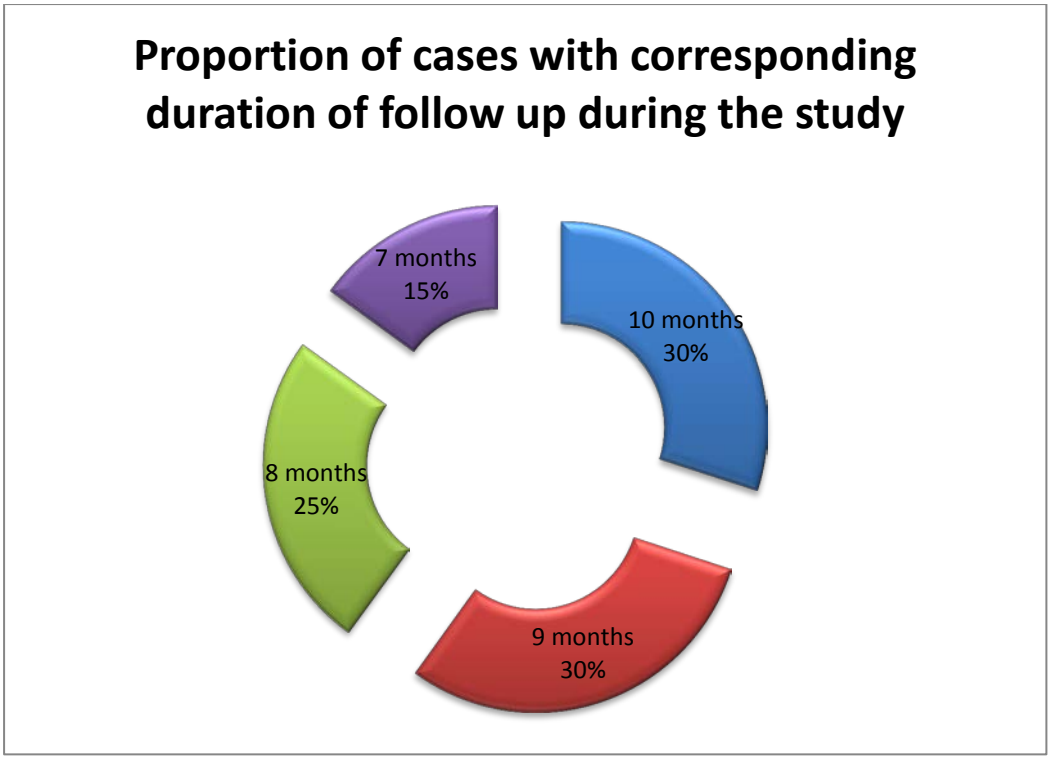
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Fourth week	72	68	77	60	77	77	65	72	79	80	65	84	77	79	77	75	70	75	77	77
Twelth week	84	82	87	77	94	84	84	86	84	84	82	90	94	89	85	87	84	88	85	85
6 th month	90	92	97	85	90	96	97	97	97	95	96	77	77	97	97	97	95	97	97	97

Final grading on completion of 6 months follow-up were

Grading	No of patients	Percentage
Poor	0	0%
Fair	2	10%
Good	3	15%
Excellent	15	75%

Follow-up:

The average duration of follow-up of the patients was 8.75 months post-operatively. The maximum duration being 10 months and the minimum being 7 months. The target was to follow-up all patients for a minimum period of 6 months, which was completed in all cases and no patient was lost in follow-up. The compliance to the post-operative protocol was satisfactory as shown in the follow-up studies involving the case series.



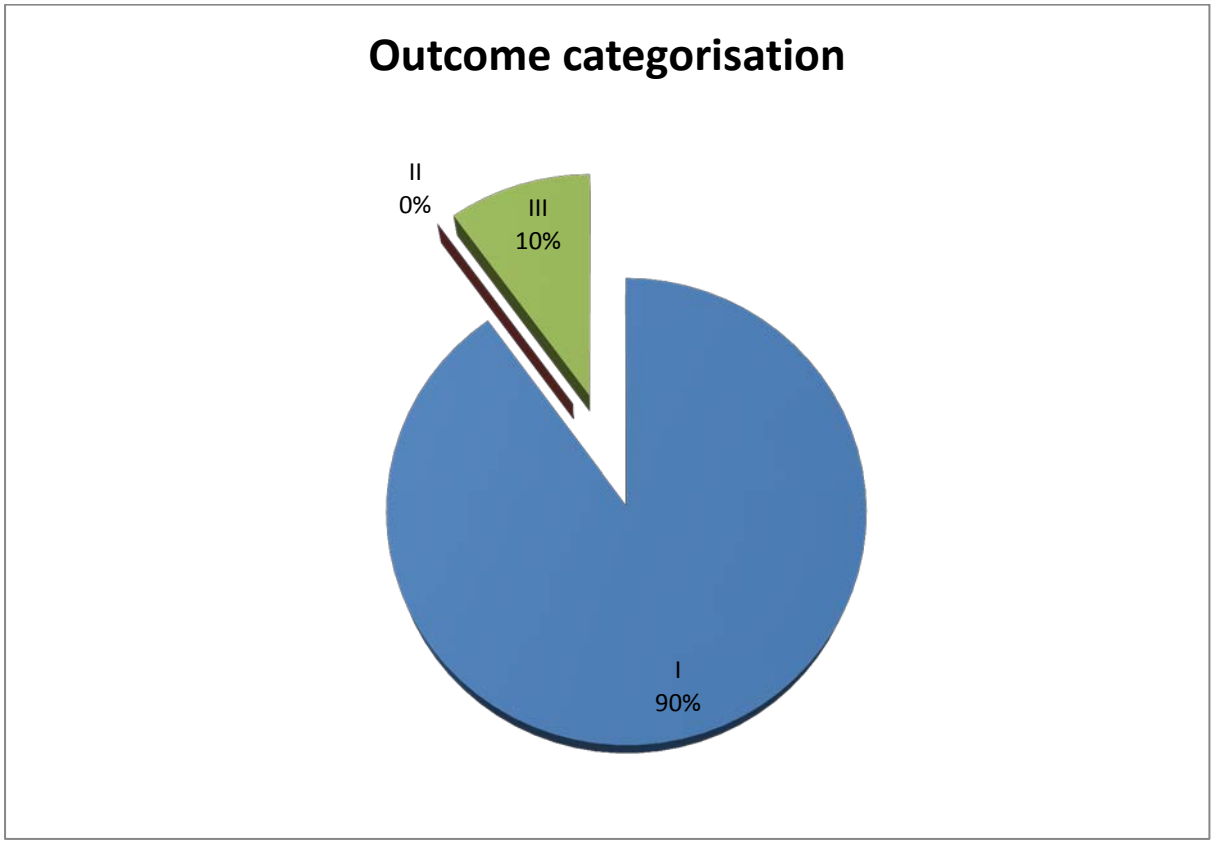
Categorisation of outcome:

As noted in the protocol for the study submitted to the hospital ethics committee the outcome was categorised as follows.

- I – Fracture united
- II – Delayed or Non-union
- III – Other complications like re-fracture, osteomyelitis etc.

There was no case of delayed union or non-union. All cases united as per the clinical and radiological criteria. There was no case of infection either superficial or deep. No incidence of osteomyelitis. There was a one case of repeated fall which required repeat surgery. One case of repeated fall which caused an ankle fracture that was managed conservatively. One case of hardware prominence, after fracture union,

which required surgery for implant exit. All these cases were brought under category III, which is defined as above.



As seen above 90% of the cases had bony union uneventfully. Though 10% of the cases had complications there was no incidence of delayed union or non-union as emphasised in the pie-chart.

Discussion

The aim of management plan of transverse fractures of patella is to provide a painless and fully functional extensor mechanism, as early as possible to make the patient return to his pre-injury level of physical work. Wide variety of options are available to achieve this target, the popular being Cerclage wiring, Magnusson wiring, Lotke-Ecker method, Pyrford method, Anterior tension band wiring, modified anterior tension band wiring, cannulated cancellous screws either alone or supplemented with tension band wiring. Controversies over the best fixation techniques for patella fractures still exist at present. The treatment of choice as of now is the Modified tension band wiring developed and popularised by the AO/ASIF group [(1) (38)]. But there have been published reports which establish the disadvantages of this technique [(43)] and have advocated alternative methods to overcome the pitfalls of the above technique. The technique of fixation of transverse fractures of patella using cannulated cancellous screws has been in vogue for some time, but there have been very few published studies to proclaim its efficiency. Especially studies that include percutaneous osteosynthesis for patella fractures are very limited.

The results obtained from the study by C.C.Chiang et al. [(7)] clearly prove the advantages of this technique. Using the Modified carpenter's technique for fixation of transverse fractures of patella on 21 knees they have obtained 86% success rate with relation to bony union and patient satisfaction. The results in our study were comparable to this study with 90% success rate. They had three cases with

complications all related to hardware issues which needed implant removal. In our study we had three cases of complications including hard ware prominence and two cases of repeated fall with one case requiring surgery for implant exit and one case for revision open surgery.

Chiang C.C et al. in another comparative study [44] involving POMC technique and Open tension band wiring technique treating a total of 60 patients with 20 in the POMC group and 40 in the OMATB group. They observed some statistically significant differences between the two groups. Namely shorter surgical time (70.4 ± 12.5), greater flexion arc (140 ± 6.1), better total range of movement (139.6 ± 8.2), higher Lysholm scores (93.6 ± 3.1) and significantly lower complication rate in the POMC group.

Metin Lufti Baydar et al. [45] conducted a biomechanical comparative analysis between three modes of fixation namely Modified tension band, malleolar screw as lag and tension band with specially designed Herbert screw. They have concluded that compression achieved by screw fixation is superior in terms of load to failure when compared with modified tension band group. This is evident in our study too involving the fixation with cannulated cancellous screws, where there is no incidence of distraction at the fracture site or leading of implant failure. The one case in our study with hardware prominence was due to the screw cut through the anterior cortex, which indicated a technical fault in positioning the screw. But the fracture went on to

unite uneventfully with the compression maintained by the other properly positioned screw. The implant exit was done to relieve the patient of the symptoms, following which the patient was symptom free.

Tandogan et al. [10] in their study involving 5 patients have come to a conclusion that POMC technique is appropriate for displaced transverse fractures of patella without wide separation and comminution. The average fracture gap in our study was 11.55 mm with a maximum separation of 20 mm. We too did not include comminuted fractures in our study. Retinacular repair was not done in both studies. The superiority of fracture compression maintained by the screws applied as lag, is evident in the early commencing of rehabilitation protocol in both studies. Tandogan also explained that early rehabilitation prevented muscular atrophy and intra-articular adhesiveness which is favourable for regaining good range of movements post-operatively. They have also demonstrated that early range of motion has some advantages for cartilage perfusion and nutrition. Only one case had less range of movements in their study whereas in our study all cases regained good range of movements. Both studies had comparable subjective results with regards to Lysholm knee scores. Both studies indicate the useful nature of the percutaneous technique in select cases with displacement.

El-Sayed AM and Ragab RK [46] in their study involving 14 displaced transverse fractures fixed with arthroscopy assisted percutaneous osteosynthesis have

obtained results similar to our study with bony union in all cases. All patients had good post-operative range of movements and excellent outcome documented by average Lysholm knee score of 93.

Makino et al. [47] treated five patients with transverse fracture pattern of patella using arthroscopy assisted percutaneous fixation with cannulated cancellous screw supplemented with anterior tension band and have concluded that interfragmentary compression is offered by the screw in all movements of the knee and when supplemented with tension band provides better fixation. This is evident in our study where there has been no incidence of fracture distraction and loss of reduction and the patients could be mobilised with passive knee range of movements the day following surgery and could bear weight with support within the first week of surgery. No incidence of non-union or delayed union in both studies.

Onder Baran et al. [13] in his biomechanical evaluation of the technique of tension band wiring with regards to the position of K-wire and the configuration of figure of eight used for tension band technique, came to a conclusion that stable construct is obtained using the position of K-wire at least 5 mm beneath the anterior surface of patella and by using the horizontal figure of eight configuration for tension band wiring. We in our study have used the same recommendations. In one case where the screw placement had been too close to the anterior cortex, had developed complication in the form of screw cut out. This proves the exactness of the findings by

Onder Baran et al. The tension band wiring by using the horizontal figure of eight configuration has proved good in all our cases to achieve union.

The study published in Indian sub-continent by Akhilesh Rathi et al. [48] includes 20 patients with transverse patella fractures treated by percutaneous osteosynthesis by Modified Tension band wiring. Except for the implants used, the surgical technique, surgical timing, post-operative protocol and results all approximately match the present the study. They have not done retinacular repair for any of their cases and also concluded that retinacular repair is not an essential part of the surgical procedure. They have also quoted other studies done on the usefulness of percutaneous patella fixation which indicate that retinacular repair is not essential to achieve bony union. Moreover none of their cases developed extensor lag post-operatively proving that transverse patella fractures fixed by percutaneous procedures heal uneventfully without retinacular repair. Similarly in our study retinacular repair was not done in any case and we have achieved bony union in all cases fixed percutaneously.

Berg and Eugene.E [11] in their study have of Open reduction and fixation of transverse patella fractures using cannulated cancellous and tension band wiring through the screw have clearly named out the disadvantages of Modified tension band wiring as a technique for open reduction. In order to prevent the migration of cerclage wiring the superior and inferior ends of the K-wires have to be bent and buried into

the quadriceps and patellar tendon. This causes soft tissue irritation making it necessary to do implant exit to relieve the patients of the symptoms [49] [50] [51]. They have also quoted two case series involving modified tension band wiring where nearly 60% of the cases required hardware removal [50] [52]. Moreover applying anterior tension band wiring through Quadriceps tendon and Patellar tendon causes these soft tissues to atrophy, due to cyclical loading, therefore leading to loss of reduction [51]. This disadvantage is overcome by performing tension band through cannulated cancellous screws as the figure of eight loop is securely fixed to the bone by the screw and the whole construct is completed as a low profile one. Moreover the screw offers static compression at fracture site and the anterior tension band wire offers dynamic compression when the knee is put through range of movement exercises. Therefore the patient can be started on early rehabilitation which is beneficial with regards to fracture union, cartilage healing, avoidance of joint stiffness and out of the bed activities for the patient. This clearly indicates the advantage of using cannulated cancellous screw like in our study where there is no incidence of implant loosening and the requirement for implant exit was only 5%.

The main reason for implant failure in cases of tension band wiring is that the fractured patella is subjected three point bending load during knee flexion. The point of contact between patella and femoral condyle acts as the fulcrum of this force and it migrates proximally on the patella, as knee flexion increases. This causes an apex anterior angulation at the fracture site [53]. But all factors are nullified by using cannulated cancellous screws and applying tension band wiring through the screws,

permitting early range of movement exercises. This contributes to the good healing of the articular cartilage [54] which reduces the chances of developing patella femoral arthritis at a later date. Berg and Eugene [11] have successfully salvaged three cases of failed implant originally fixed with Modified Tension Band wiring, by redo surgery using cannulated screws supplemented with anterior tension band wiring through the screws. They have concluded that this method of fixation is most appropriate for transverse fracture pattern with two large fragments, is compatible with early range of motion particularly advantageous in cases of osteoporosis in old age.

A level III evidence (Therapeutic study) provided by Yun Tian et al. [12] confirms the usefulness of this method of fixation. In their prospective and therapeutic comparative study involving 101 patients, they have divided the population into two groups. One fixed with standard Modified tension band wiring and the other group fixed with cannulated cancellous screws and anterior tension band wiring. The main difference from our study being the implant material and mode of surgery. In our study we have used stainless steel material whereas they have used screws and cables both made of titanium. Our study involves percutaneous technique whereas they study involves open surgery. The mean interfragmentary gap was 15.85 ± 7.95 in the modified tension band group and 16.78 ± 5.37 in the Cannulated screw – cable group. Significantly more than the mean interfragmentary gap in our study which was 11.55 mm. Since being open surgery they had no difficulty getting the reduction of the fracture fragments, which was the most difficult step in our study. All other surgical

steps being similar to our study, for the cannulated screw – cable group. The objective analysis was done using clinical and radiological assessment. But the subjective analysis done using Iowa knee scoring system. Since both groups in their study underwent open surgery they did not observe any significant difference in surgery time between the two groups. But five patients in K-wire group experienced soft tissue irritation and three required implant exit. No such incidence in the screw group. The post-operative interfragmentary gap was significantly more in the K-wire group. Three patients in the K-wire group required salvage by re-operation using cannulated screws and cable and united eventually. They also observed better Iowa knee score in the cannulated screw – cable group. They also observed that irrespective of the position of the screw from the anterior surface of patella, the cable when applied through the screw gave better and uniform compression to the anterior surface, during knee range of movements which aided in better healing of the fracture. Finally they concluded that Cannulated screw and cable through the screw as tension band is better alternative method of fixation of transverse patellar fractures with less complication rates.

The most important and famous study that supports the finding of our study is by Carpenter himself [(9)] based on whose study this work is done with modification from open surgery to percutaneous procedure. Carpenter et al. in his biomechanical analysis to determine which construct has the best fixation strength comparing three methods namely OMATB, Lag screws alone and cannulated screw as lag supplemented with anterior tension band wiring through the screws. His results were

that the cannulated screw – TBW group had the maximum failure resistance (Mean of 732 newtons) followed by the screws only group (Mean of 554 newtons) and the OMATB group (mean of 395 newtons). This finding is confirmed in our study which had no incidences of post-operative fracture separation though the patients started mobilisation the day following surgery and were able to bear weight with support mostly on the second day.

Having discussed all the advantages of the technique involved in our study we need to emphasize the few difficulties which we experienced. First of all was getting the fracture reduction. Closed manipulation was easier in lean individuals and satisfactory reduction could be achieved is short time. On the contrary closed surgery on obese patients and female patients with more subcutaneous fat was much difficult with regards to fracture reduction. We had to use two separate clamps to handle the individual fragments, bring them into reduction and hold it with a third reduction clamp. Further passing the guide wire with such large clamps was cumbersome though not possible. After satisfactory positioning of the guide wires the remaining procedure took almost the same time in all patients. As illustrated in our observations the surgical timing for individual case gradually declined as we gained more experience in the steps involved in the surgical procedure.

One other issue was with regards to patient compliance to post-operative protocol. It was very important to make the patient clearly understand the do’s and

don’t’s following surgery and also strictly adhere to the advice regarding weight bearing with or without support depending on the timing since surgery. We had two incidences of repeat fall with one resulting in redo surgery and one resulting in ankle fracture that was managed conservatively.

Summary & conclusion

This prospective study involved 20 patients admitted at Government Kilpauk Medical College, Chennai – 10. The patients had closed transverse two part fracture (AO Type 34C1) of the patella and were operatively managed with Percutaneous Osteosynthesis using Modified Carpenter's technique, which involves closed manipulative reduction of fracture with arthroscopy and fluoroscopy assistance and internal fixation using 4.0 mm cannulated cancellous screw system supplemented with percutaneous tension band wiring using 18G stainless steel wire. The patients were followed for a minimum period of 6 months during which they were advised a standard post-operative protocol. During and on completion of the follow-up period the patients were objectively assessed by clinico-radiological examination and subjectively assessed using Lysholm knee scoring system. The hospital inpatient records, operative notes, follow-up notes and x-rays were thoroughly evaluated to arrive at the observation and inferences. There was one case of hard-ware prominence which necessitated implant removal by second surgery. There was no incidence of superficial or deep infection until last follow-up. The overall results showed that 75% of the patients had excellent results by subjective analysis using the Lysholm knee scoring scale and 90% union rate (Category I outcome) by clinic-radiological assessment.

Transverse fractures of patella being the most commonly encountered pattern among patellar fractures had been treated with various options in the past. There had been continuous evolution in the techniques of fixation of this fracture. The recent advocates of minimally invasive surgery insist on respecting the soft tissue surrounding the bone and fracture to maintain vascularity and to aid in faster and better healing of the same to achieve bony union.

This technique of Percutaneous Osteosynthesis by Modified Carpenter's technique has significant advantage of being a minimally invasive procedure with the most rigid form of fixation presently available. Moreover the pre-requisites in treating an intra-articular fracture namely anatomical reduction and stable, rigid fixation are both fulfilled. Arthroscopic examination of the knee joints serves two purposes. The first being evacuation of hemarthrosis and secondly the confirmation of perfect anatomical alignment of the fracture fragments. The rigidity of the construct being proved beyond doubts by the outcomes of this study as well as the detailed review of published literature. The cosmetic advantage offered to the patient in the form of minimal incision over the knee instead of the long linear scar as done with standard open reduction and internal fixation.

The shortfall of our study is that it is a short term outcome analysis. Moreover there are few publications explaining the advantages of the POMC technique but it just a matter of time before long term follow-up studies get published to establish the role of POMC technique in management of closed and displaced transverse patellar fractures.

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Appendix

PATIENT CONSENT FORM - ENGLISH

Study detail: "SHORT TERM OUTCOME ANALYSIS OF ARTHROSCOPY ASSISTED PERCUTANEOUS OSTEOSYNTHESIS FOR PATELLA FRACTURES"

Study centre : KILPAUK MEDICAL COLLEGE, CHENNAI

Patients Name :

Patients Age :

Identification Number :

Patient may check (√) these boxes

I confirm that I have understood the purpose of procedure for the above study. I had the opportunity to ask question and all my questions and doubts have been answered to my complete satisfaction. ☐

I understand that my participation in the study is voluntary and that I am free to withdraw at any time without giving reason, without my legal rights being affected. ☐

I understand that sponsor of the clinical study, others working on the sponsor's behalf, the ethical committee and the regulatory authorities will not need my permission to look at my health records, both in respect of current study and any further research that may be conducted in relation to it, even if I withdraw from the study I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study. ☐

I hereby make known that I have fully understood the use of above surgical procedure, the possible complications arising out of its use and the same was clearly explained to me and also understand that this technique is a new method of treatment of patella fractures and this study is done to know the usefulness of the same in management of patella fractures ☐

I agree to take part in the above study and to comply with the instructions given during the study and faithfully cooperate with the study team and to immediately inform the study staff if I suffer from any deterioration in my health or well-being or any unexpected or unusual symptoms. ☐

I hereby consent to participate in this study. ☐

I hereby give permission to undergo complete clinical examination and diagnostic tests including hematological, biochemical, radiological tests. ☐

Signature/thumb impression:

Patients Name and Address: Place Date

Signature of investigator :

Study investigator's Name : Place Date

நோயாளி ஒப்புதல் படிவம்

ஆராய்ச்சியின் விவரம்: முழங்கால் மூட்டு சில் எலும்பு முறிவிற்கு துளை-முட்டு அறுவை சிகிச்சை சாதன உதவியுடன் நுன்துளை அறுவை சிகிச்சையின் பயன்களை அறியும் ஆய்வரிக்கை

ஆராய்ச்சி மையம்: அரசு கீழ்பாக்கம் மருத்துவக் கல்லூரி மருத்துவமனை

நோயாளியின் பெயர்: நோயாளியின் வயது:

பதிவு எண்:

நோயாளி கீழ்கண்டவற்றுள் கட்டங்களை (✔) செய்யவும்

1. மேற்குறிப்பிட்டுள்ள ஆராய்ச்சியின் நோக்கத்தையும் பயனையும் முழுவதுமாக புரிந்துகொண்டேன். மேலும் எனது அனைத்து சந்தேகங்களையும் கேட்டு அதற்கான விளக்கங்களையும் தெளிவுபடுத்திக் கொண்டேன். ☐

2. மேலும் இந்த ஆராய்ச்சிக்கு எனது சொந்த விருப்பத்தின் பேரில் பங்கேற்கிறேன் என்றும், மேலும் எந்த நேரத்திலும் எவ்வித முன்னறிவிப்புமின்றி இந்த ஆராய்ச்சியிலிருந்து விலக முழுமையான உரிமை உள்ளதையும், இதற்கு எவ்வித சட்ட பிணைப்பும் இல்லை என்பதையும் அறிவேன். ☐

3. ஆராய்ச்சியாளரோ, ஆராய்ச்சி உதவியாளரோ, ஆராய்ச்சி உபயத்தாரோ, ஆராய்ச்சி பேராசிரியரோ, ஒழுங்குநெறி செயற்குழு உறுப்பினர்களோ எப்போது வேண்டுமானாலும் எனது அனுமதியின்றி எனது உள்நோயாளி பதிவுகளை இந்த ஆராய்ச்சிக்காகவோ அல்லது எதிர்கால பிற ஆராய்ச்சிகளுக்காகவோ பயன்படுத்திக்கொள்ளலாம் என்றும், மேலும் இந்த நிபந்தனை நான் இவ்வாரய்ச்சியிலிருந்து விலகினாலும் தகும் என்றும் ஒப்புக்கொள்கிறேன். ஆயினும் எனது அடையாளம் சம்பந்தப்பட்ட எந்த பதிவுகளும் (சட்டபூர்வமான தேவைகள் தவிர) வெளியிடப்படமாட்டாது என்ற உறுதிமொழியின் பெயரில் இந்த ஆராய்ச்சியிலிருந்து கிடைக்கப்பெறும் முடிவுகளை வெளியிட மறுப்பு தெறிவிக்கமாட்டேன் என்று உறுதியளிக்கின்றேன். ☐

4. இந்த ஆராய்ச்சிக்கு நான் முழுமனதுடன் சம்மதிக்கின்றேன் என்றும் மேலும் ஆராய்ச்சிக் குழுவினர் எனக்கு அளிக்கும் அறிவுரைகளை தவறாது பின்பற்றுவேன் என்றும் இந்த ஆராய்ச்சி காலம் முழுவதும் எனது உடல் நிலையில் ஏதேனும் மாற்றமோ அல்லது எதிர்பாராத பாதகமான விளைவோ எற்படுமாயின் உடனடியாக ஆராய்ச்சி குழுவினரை அணுகுவேன் என்றும் உறுதியளிக்கின்றேன். ☐

5. இந்த ஆராய்ச்சிக்குத் தேவைப்படும் அனைத்து மருத்துவப் பரிசோதனைகளுக்கும் ஒத்துழைப்பு தருவேன் என்று உறுதியளிக்கின்றேன். ☐

6. இந்த ஆராய்ச்சிக்கு யாருடைய வற்புருத்தலுமின்றி எனது சொந்த விருப்பத்தின் பேரிலும் சுயஅறிவுடனும் முழுமனதுடனும் சம்மத்திக்கின்றேன் என்று இதன் மூலம் ஒப்புக்கொள்கிறேன். ☐

நோயாளியின் கையொப்பம் / பெருவிரல் கைரேகை ஆராய்ச்சியாளரின் கையொப்பம்

இடம்: தேதி:

PROFORMA

Name :

Age / Sex :

IP number :

Address :

Contact Number :

Date of Admission :

Date of Surgery :

Date of Discharge :

Occupation :

Education :

Socioeconomic Status :

Diagnosis :

Procedure Done :

Outcome : I/II/III
I – Fracture united
II – Delayed or Non-union
III – Other complications like refracture, osteomyelitis etc.

HISTORY:

1. Mode of injury : Road traffic accident / Fall at home / Fall from height / Assault

2. Presenting complaints :
    a. Pain – site / duration
    b. Swelling – site / extent
    c. Deformity
    d. Disturbances in function – movements
    e. Other associated injuries – head injury / limb injuries / spine injuries
3. Comorbid illnesses :

Diabetes mellitus		Hypertension		Coronary heart disease	
Renal disorder		Seizures /Neurological disorder		Hepatic disorder	
Dyslipedemia		Endocrine disorder		Tuberculosis	
Bronchial Asthma		Chronic Obstructive lung diseases		Neoplastic disorders	

4. Drug history : Steroids / Disease modifying anti-rheumatoid drugs / Immunosuppresants

PAST HISTORY:

- Any similar injuries
- Previous surgeries or hospitalisations
- Any major illnesses

PERSONAL HISTORY:

Diet	Vegetarian / Mixed
Marital Status	Married / Single
Bowel and Bladder habits	Regular / Altered
Habits	Smoking / Alcohol / Tobacco / Drug Addictions / Others

OBSTETRIC & GYNAECOLOGY HISTORY:

TREATMENT HISTORY:

FAMILY HISTORY:

CLINICAL EXAMINATION:

GENERAL EXAMINATION:

- ☞ Appearance :
- ☞ Built :
- ☞ Pallor :
- ☞ Icterus :
- ☞ Cyanosis :
- ☞ Clubbing :
- ☞ Pedal Edema :
- ☞ Lymphadenopathy :

VITALS:

1. Pulse :
2. BP :
3. Respiratory rate :
4. Temperature :

SYSTEMIC EXAMINATION :

- ☞ Cardiovascular system :
- ☞ Respiratory system :
- ☞ Abdomen :

REGIONAL EXAMINATION

RIGHT / LEFT KNEE

OTHER INJURIES

X – RAY FINDINGS

INVESTIGATIONS

Hb%		TC		DC	P L B E M
ESR		BT/CT		RBS	
UREA		S.CREATININE		ELECTROLYTES	Na^+ K^+
HBsAg		HIV		VDRL	
CXR		ECG		URINE ROUTINE	
Blood G & T				ALBUMIN SUGAR DEPOSITS	

FINAL DIAGNOSIS:

INITIAL TREATMENT GIVEN:

PLANNED SURGERY :

PROCEDURE NOTES

POST OP PERIOD

FOLLOW UP (After discharge)	CLINICAL FINDINGS	X–RAY FINDINGS	ADVICE
FIRST WEEK			
SECOND WEEK			
FIRST MONTH			
SECOND MONTH			
THIRD MONTH			
SIXTH MONTH			

OUTCOME:

LKSS

LYSHOLM KNEE SCORING SCALE

Instructions: Below are common complaints which people frequently have with their knee problems. Please check the statement which best describes your condition.

I. LIMP:
_____ **I have no limp when I walk. (5)**
_____ **I have a slight or periodical limp when I walk. (3)**
_____ **I have a severe and constant limp when I walk. (0)**

II. USING CANE OR CRUTCHES
_____ **I do not use a cane or crutches. (5)**
_____ **I use a cane or crutches with some weight-bearing. (2)**
_____ **Putting weight on my hurt leg is impossible. (0)**

III. LOCKING SENSATION IN THE KNEE
_____ **I have no locking and no catching sensations in my knee. (15)**
_____ **I have catching sensation but no locking sensation in my knee. (10)**
_____ **My knee locks occasionally. (6)**
_____ **My knee locks frequently. (2)**
_____ **My knee feels locked at this moment. (0)**

IV. GIVING WAY SENSATION FROM THE KNEE
____ **My knee never gives way. (25)**
____ **My knee rarely gives way, only during athletics or other vigorous activities. (20)**
____ **My knee frequently gives way during athletics or other vigorous activities, in turn I am unable to participate in these activities. (15)**
____ **My knee occasionally gives way during daily activities. (10)**
____ **My knee often gives way during daily activities. (5)**
____ **My knee gives way every step I take. (0)**

V. PAIN:
____ **I have no pain in my knee. (25)**
____ **I have intermittent or slight pain in my knee during vigorous activities. (20)**
____ **I have marked pain in my knee during vigorous activities. (15)**
____ **I have marked pain in my knee during or after walking more than 1 mile. (10)**
____ **I have marked pain in my knee during or after walking less than 1 mile. (5)**
____ **I have constant pain in my knee. (0)**

VI. SWELLING
____ **I have no swelling in my knee. (10)**
____ **I have swelling in my knee only after vigorous activities. (6)**
____ **I have swelling in my knee after ordinary activities. (2)**
____ **I have swelling constantly in my knee. (0)**

VII. CLIMBING STAIRS:
____ **I have no problems climbing stairs. (10)**
____ **I have slight problems climbing stairs. (6)**
____ **I can climb stairs only one at a time. (2)**
____ **Climbing stairs is impossible for me. (0)**

VIII. SQUATTING
____ **I have no problems squatting. (5)**
____ **I have slight problems squatting. (4)**
____ **I can not squat beyond a 90 degree bend in my knee. (2)**
____ **Squatting is impossible because of my knee. (0)**

TOTAL_____/100

INSTRUCTIONS: Please place an X on the line to indicate the amount of pain you have had in your knee(s) the past 24 hours. The scale ranges from "no pain at all" to the "worst possible pain".

RIGHT KNEE _____

no pain worst possible pain

LEFT KNEE _____

no pain worst possible pain

Ethical committee Clearance

INSTITUTIONAL ETHICAL COMMITTEE
GOVT.KILPAUK MEDICAL COLLEGE,
CHENNAI-10
Ref.No.161/ME-1/Ethics/2013 Dt:07.02.2013.
CERTIFICATE OF APPROVAL

The Institutional Ethical Committee of Govt. Kilpauk Medical College, Chennai reviewed and discussed the application for approval "A Study on Short term outcome analysis of arthroscopy assisted percutaneous osteosynthesis for patella fractures" for dissertation purpose submitted by Dr. S. Cheralathan, MS (Orthopaedics), PG Student, Govt. Kilpauk Medical College, Chennai.

The Proposal is APPROVED.

The Institutional Ethical Committee expects to be informed about the progress of the study any Adverse Drug Reaction Occurring in the Course of the study any change in the protocol and patient information /informed consent and asks to be provided a copy of the final report.

12/2/13

CHAIRMAN,
Ethical Committee
Govt.Kilpauk Medical College,Chennai

GOVT. KILPAUK MEDICAL COLLEGE
12 FEB 2013
Kilpauk, Chennai-10.

11/2

Master chart

Sl.No	Name	THESIS MASTER CHART Age	Sex	Mode of injury	Side affected	Level of fracture
1	Mr.A	47	M	Self-fall	Right	Middle
2	Mr.Mu	32	M	RTA	Left	Middle
3	Mr.Si	27	M	RTA	Right	Middle
4	Mr.Na	21	M	RTA	Both sides	Middle
5	Mrs.K	55	F	Self-fall	Right	Middle
6	Mr.Su	39	M	Self-fall	Right	Proximal
7	Mrs.Mar	60	F	Self-fall	Right	Middle
8	Mr.Kan	30	M	RTA	Left	Middle
9	Mr.Kes	21	M	RTA	Right	Middle
10	Mrs.Lak	55	F	Self-fall	Left	Distal
11	Mrs.R	62	F	Self-fall	Left	Middle
12	Mrs.Se	50	F	Self-fall	Left	Middle
13	Mr.La	50	M	Self-fall	Left	Middle
14	Mr.S	24	M	RTA	Right	Middle
15	Mrs.P	62	F	Self-fall	Right	Middle
16	Mr.C	59	M	Self-fall	Left	Middle
17	Mr.Ra	20	M	RTA	Left	Middle
18	Ms.B	18	F	RTA	Right	Middle
19	Mr.G	59	M	Self-fall	Left	Middle
20	Mr.Mo	33	M	RTA	Left	Middle

THESIS MASTER CHART

Sl.No	Comorbid illness	Other associated injuries	Time gap between injury and surgery (days)
1	DM	Nil	2
2	Nil	Distal Radius fracture Left	2
3	Nil	Nil	1
4	Nil	Bilateral patella fracture : Right side open injury and left side closed injury	1
5	Nil	Nil	3
6	Nil	Nil	2
7	IHD	Distal Radius fracture Right	5
8	Nil	Nil	1
9	Nil	Nil	2
10	HT	Nil	5
11	DM	Nil	6
12	HT	Nil	5
13	Nil	Nil	1
14	Nil	Nil	1
15	DM	Nil	4
16	HT	Nil	1
17	Nil	Nil	2
18	Nil	Nil	1
19	DM/HT/IHD	Nil	5
20	Nil	Nil	1

THESIS MASTER CHART

Sl.No	Fracture Gap (mm)	Surgery time	Post op Gap (mm)	Articular surface alignment	Passive ROM exercises (POD)
1	7	90	1	Good	1
2	5	80	1	Good	1
3	5	90	0	Good	1
4	4	70	0	Good	1
5	10	75	1	Good	1
6	11	85	0	Good	1
7	10	70	1	Good	2
8	10	70	0	Good	1
9	15	55	1	Good	1
10	12	60	1	Good	1
11	8	45	1	Good	2
12	10	65	1	Good	1
13	12	55	1	Good	2
14	12	50	1	Good	1
15	12	45	1	Good	2
16	14	45	0	Good	1
17	20	60	1	Good	1
18	18	45	1	Good	1
19	12	60	1	Good	2
20	14	50	0	Good	2

THESIS MASTER CHART

Sl.No	Full weight bearing with brace (POD)	Knee ROM after union	Time for fracture union (weeks)	LKSS Fourth week
1	2	120	14	72
2	5	140	12	68
3	2	130	12	77
4	12	140	14	60
5	2	140	14	77
6	3	130	12	77
7	3	120	16	65
8	2	130	12	72
9	2	140	12	79
10	3	120	14	80
11	3	120	14	65
12	2	130	14	84
13	3	130	14	77
14	2	140	12	79
15	3	120	14	77
16	2	120	14	75
17	2	140	12	70
18	2	140	12	75
19	4	130	14	77
20	2	140	12	77

THESIS MASTER CHART

Sl.No	LKSS Twelfth week	LKSS 6 th month	Complications	Outcome category	Last follow up (Months)
1	84	90	Nil	I	10
2	82	92	Nil	I	10
3	87	97	Nil	I	10
4	77	85	Nil	I	10
5	94	90	Ankle fracture	III	10
6	84	96	Nil	I	10
7	84	97	Nil	I	9
8	86	97	Nil	I	9
9	84	97	Nil	I	9
10	84	95	Nil	I	9
11	82	96	Nil	I	9
12	90	77	Repeat fall	I	9
13	94	77	Prominent hardware	III	8
14	89	97	Nil	I	8
15	85	97	Nil	I	8
16	87	97	Nil	I	8
17	84	95	Nil	I	8
18	88	97	Nil	I	7
19	85	97	Nil	I	7
20	85	97	Nil	I	7

ABBREVIATIONS

POMC	PERCUTANEOUS OSTEOSYNTHESIS BY MODIFIED CARPENTER'S TECHNIQUE	TBW	TENSION BAND WIRING
LKSS	LYSHOLM KNEE SCORING SCALE	ITB	ILIOTIBIAL TRACT